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THE MINERALOGICAL MAGAZINE

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Notes on the mineral deposits of the Teign valley, Devon.

By Lieut.-Colonel J. V. Ramsden, C.M.G., D.S.O.

[Read January 25, 1945.]

RESEARCH into the history of the old mines suggests that two mineralized fissuring systems intersect in central Devon, often carrying commercial e-bodies. The older of these is the east–west system usually carrying copper, on, or tin, which has been extensively worked in west Devon, but is less eveloped on the eastern flank of the Dartmoor granite massif.

The younger north–south series, characterized by its lead and silver ores and aryte is particularly well developed in the Teign valley. This band of mineraliza- on can be traced from the north of Scotland through Brittany and Spain to lgeria. In Devon it appears to be divided into three main fissure bands:

1. Combe Martin to Plymouth.
2. North Molton to Spreyton, with a possible extension south of the Dartmoor granite.
3. Molland to Newton St. Cyres and the Teign valley.

There appear to be other similar bands farther east, now buried under esozoic rocks:

4. Watchet to Sidmouth: baryte has been found at Watchet (specimen in the Taunton Museum); sandstone cemented with baryte at Langley near Wiveliscombe;[1] baryte in cavities in the Carboniferous Limestone quarries at Burlescombe;[2] sandstone cemented with celestine at Sidmouth.[3]
5. Mendips to Lyme Regis: baryte at Cannington Park;[4] sandstone cemented by baryte in bore at Lyme Regis.[3]

Plotting the sites of former mining activities shows that these coincide in a ost interesting way with the intersections of the north–south and east–west sure systems.

Superimposed on these two systems is a third which can be traced almost ntinuously round the Dartmoor granite for a distance of about a mile from e edge of the latter. Presumably it was caused by the contraction of the anite mass as it cooled. At many places it coincides with the other two systems d is strongly mineralized.

The deposition of barium sulphate.—To understand the mineralization of the

[1] Mem. Geol. Survey, Quantock Hills, 1908, Sheet 295.
[2] W. Downes, Trans. Devon Assoc., 1883, vol. 15, p. 453.
[3] Mem. Geol. Survey, Sidmouth and Lyme Regis, 1911, Sheets 326 & 340.
[4] Mem. Geol. Survey, Spec. Rep. Min. Res., 1922, vol. 2, 3rd edit., p. 95. F. S. Wallis, ol. Mag., 1924, vol. 61, p. 218. [M.A. 2–464.]

north–south vein system, the writer has endeavoured to collect all availa information on the probable processes which caused these deposits. While deposition of galena and pyrite has been fully described,[1] that of baryte has been so well dealt with. Von Engelhardt[2] has brought to bear on this quest the great advances of chemical knowledge of the last four decades. He sh that, the barium atom being closely similar in size to that of potassium, i cooling magma the barium silicates will crystallize out as felspars (celsian hyalophane) slightly earlier than the potash-felspars, but that mixed cry will generally be formed. The practical application of this is that bari deposits may be expected in the neighbourhood of granite or syenite. Bari micas also crystallize out from the cooling magma.

Both barium-felspars and micas are easily decomposed by rain water char with carbon dioxide, the barium being taken into solution as a soluble bica nate. These solutions, as they flow away into rivers, will meet sulphate i from the decomposition of pyrite, but the precipitation of the barium sulp will be hindered by other ions present, and will only take place when colloidal attraction of the fine muds, being deposited far out at sea, provi the necessary conditions for it to be completed.

Such a process, however, hardly accounts for the large masses of bar found in fissure veins. In these cases the most probable explanation, whic owe to Dr. K. C. Dunham, is that the sulphate radical was also evolved f the cooling magma, and that the barium sulphate came up as a colloidal solut of high concentration. This would fit in with the ideas put forward by Spu and with the fact that large blocks of wall-rock (sp. gr. 2·25) are found entir unsupported in the massive baryte (sp. gr. 4·0) in the Teign valley mines. Th weight seems to have been entirely supported by their buoyancy in the ascend ore solution, and there is some evidence that they may have even been car upwards by the rising currents. Baryte seems to have been deposited in highest parts of the existing fault fissures, which were probably further ope by the pressure of the rising solution and later by the forces generated by crystallization of the solid ore.

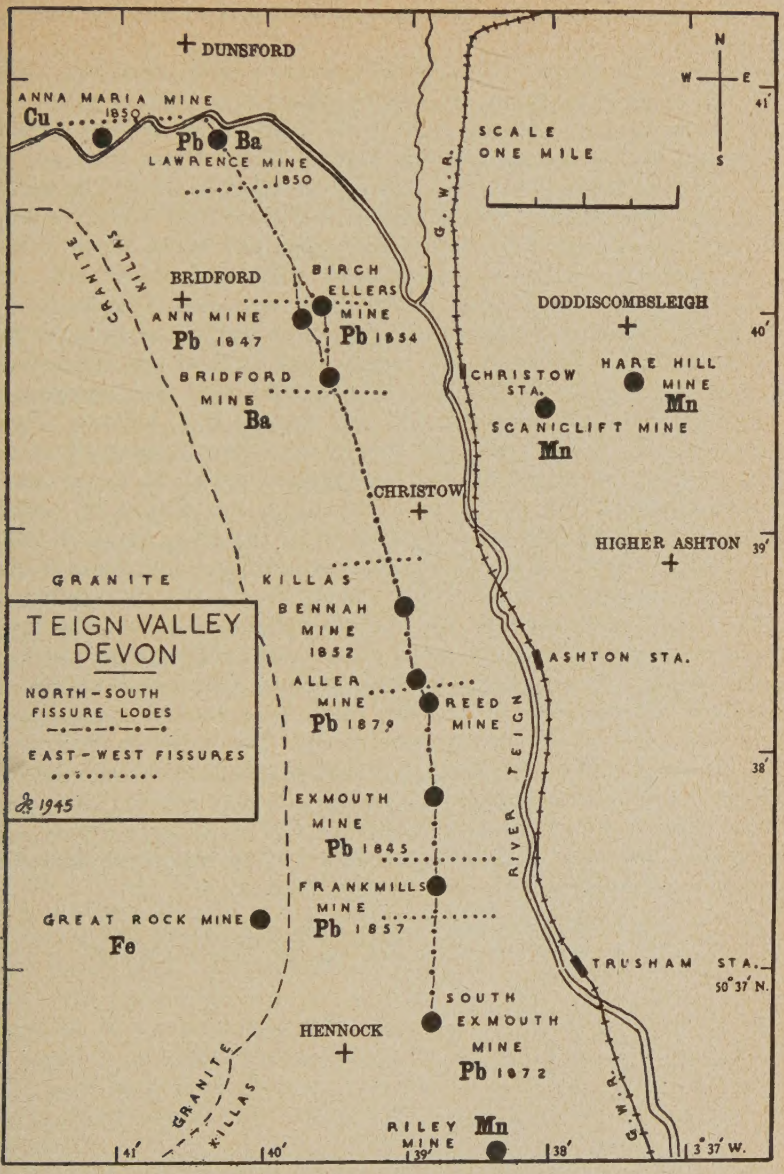
The baryte of the veins is mostly microcrystalline, but in many places pl crystals of some size have developed suggesting that at these spots there less disturbance of the solution. In the higher parts of the veins there much botryoidal baryte in spherical masses of large diameter. These sho concentric bands of metallic sulphides arranged as Liesegang rings. Appare as the barium sulphate crystallized out of the colloidal solution, the concen tion of the metallic sulphides increased till a point was reached when the their turn started to crystallize out till their concentration was so diminis that the barium sulphate could again crystallize out unhindered.

Lead.—It is unfortunate that there is little detailed information of manner in which the galena occurred in the lead mines of the Teign val In the Bridford mine pieces of any appreciable size are rare, the lead extracted when the mine was being worked in the early fifties of last cen

[1] F. W. Clarke, Data of geochemistry, 3rd edit., Bull. U.S. Geol. Survey, 1916, no. pp. 537–539 and 579–581.

[2] W. von Engelhardt, Die Geochemie des Barium. Chemie der Erde, 1936, vol. 10, pp. 246. [M.A., 6–296.]

[3] J. E. Spurr, The ore magmas. New York, 1923.



eems to have been as small crystals in pockets between the wall-rock and the aryte veins. Judging from specimens found on the dumps, at Frankmills and ixmouth mines, one vein had a silica gangue, in which the galena was in more olid form, and occasionally in veins six inches wide. The galena was argenti- erous, some 37,000 tons of lead ore having produced 250,000 ounces of silver etween 1845 and 1880.

Blende.—This is constantly found as small disseminated crystals in the

Bridford baryte veins, but so far the quantities present have no commerci significance.

Strontium.—The baryte of this district contains a small percentage, probabl up to 2 %, of the isomorphous strontium sulphate.

Micaceous iron-ores.—Farther south in the Teign valley, as part of the eas west system, lie the specular iron-ore deposits of the Great Rock and Ke mines.[1] The ore is presumably of pneumatolytic origin as the granite wall-roc are heavily tourmalinized.[2] These east–west iron-ore veins are fairly freque along the eastern flank of the Dartmoor granite, and in the Bovey Tracey Moreton Hampstead valley they occasionally carry cassiterite or rutile. Clar (loc. cit.) fully discusses the geochemistry of the formation of haematite.

Manganese deposits.—These deposits from near Doddiscombsleigh to Asht on the east bank of the Teign, and farther south at Riley and Huish Cross the west bank, are particularly interesting as they have their counterpart the west side of the Dartmoor massif, near Brentor and Chillaton. The we known Huxham, Upton Pyne, and Newton St. Cyres deposits are in a ve which obviously belongs to the east–west fissure system. It would seem th the manganese has been derived from ferromanganese silicates by solution bicarbonate, and then deposited with much of the silica dissolved from t same source, as bodies of manganese ores are associated with massive chert.

The killas shale wall-rock.—The fissures in the Teign valley are usually inclin within some 10° of the vertical. The walls show slickensides, but so far there h been no means of measuring the actual displacement of these fissure faults. T general impression is that the displacement was only a few feet. The killas sha which form the wall-rocks of the Teign valley veins are little more than mu stones with some disseminated grains of pyrite. This pyrite in the presence damp air easily oxidizes, breaking up the shale into mud, which causes mu difficulty in maintaining underground passages. It may well be that at the ti of mineralization, the rocks were permeated with water vapour and partia decomposed, making a weak, almost viscous medium into which the ascendi solutions could easily expand and form wide ore-deposits.

[1] F. B. Michell, Mine and Quarry Engineering, January 1945.
[2] Mem. Geol. Survey, Spec. Rep. Min. Res., 1919, vol. 9, p. 47.

Myrmekite in graphic granite and in vein perthite.

(With Plates VI and VII.)

By Edmondson Spencer, D.Sc., A.R.S.M., F.R.I.C., F.G.S.

[Read March 22, 1945.]

1. Introduction.

THIS paper describes the occurrence of myrmekite in a graphic quartz-microcline-rock from the mica-bearing pegmatites of Kodarma, Bihar, India. he myrmekite has grown out from the quartz-microcline junctions into the otash-felspar with the appearance of having replaced the latter. The two are in ptical and crystallographic continuity and, owing to the large 'single crystal' haracter of the microcline, definitely oriented sections can readily be prepared. detailed study of these sections shows that the myrmekite has been formed y the segregation and coalescence of microperthitic albite formerly held in solid olution in the potash-felspar. Successive stages in this process of segregation can e observed.

These sections also provide evidence of the paragenetic relationship between ie quartz rods, the vein perthite,[1] and the body microcline. This is supplemented y additional evidence from graphic granites and vein perthites obtained from her localities.

2. Kodarma Graphic Granite.

(*a*) *Megascopic characters.*

This rock was obtained from a road-cutting near the Ramchance mica mine, odarma. At the time of collecting the specimens, the newly made cutting posed a cross-section of at least 40 feet of pegmatite which consisted almost ntirely of quartz and microcline in graphic intergrowth. As is usual with these aphic intergrowths the whole of the microcline apparently consisted of one ystal. The texture varies in size from two or three inches across individual nds down to several to the inch. Where unweathered the microcline of this aphic rock is colourless and translucent to nearly clear, cleavage fragments to $\frac{1}{8}$ inch being glass clear when viewed along the *b* and *c* directions, but rbid along the *a*-axis. The quartz rods are clear and moderately free from clusions.

When a specimen of this rock is ground and polished parallel to the (001) rection of the microcline, the felspar portion shows an uneven pearly or satiny hiller. This unevenness becomes very marked when the polished surface is

[1] Throughout this paper Andersen's term 'vein' perthite has been used when referring to coarser variety of perthitic albite lamellae found in pegmatitic microcline. This term pears to have received general acceptance amongst petrographers, although, as Alling has nted out, it may at times lead to confusion. His alternative term 'band' perthite, is not ctly descriptive of these lamellae, since they are usually lenticular in form and often anged in echelon.

viewed by point-source oblique illumination, as may be seen from text-fig. 1, t
bright and shaded portions being microcline, the quartz rods being shown
black. The puckered or 'rucked up' appearance of the microcline surface is d
to a local distortion of the basal and perthite planes. This distortion is m
pronounced near the contact with the quartz rods.

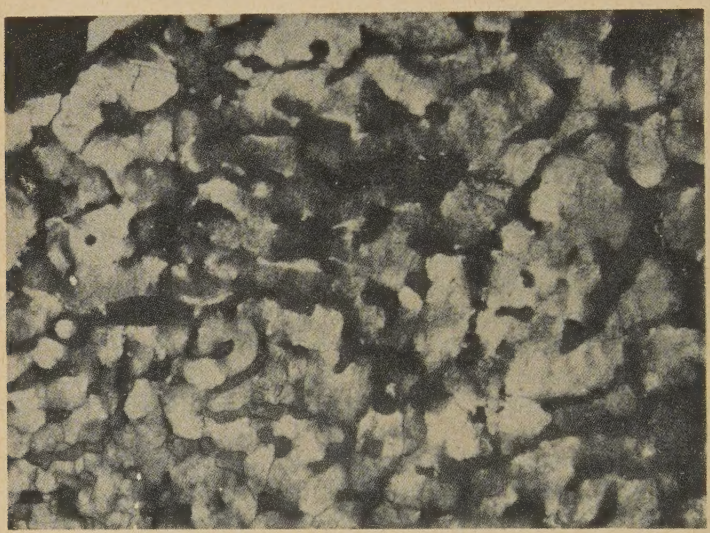


FIG. 1. Graphic granite, Kodarma, India, ground and polished on (001), viewed by oblique illumination. Shows internal distortion of perthite and basal planes of the microcline. Natural size.

(*b*) *Description of microscope sections.*

As the myrmekite intergrowths in these pegmatitic microclines, together wi
the vein perthite, are believed by the writer to have been derived mainly fro
microperthitic albite by a process of segregation and coalescence, the eviden
for this segregation, as seen in sections, will be given in some detail before descri
ing the myrmekite bodies.

Sections on (001).—In ordinary light, sections on (001) of the microcline porti
of the graphic rock show fine evenly distributed microperthitic lamellae wi
occasional larger units of vein perthite. The microperthite is finer in size than
many microclines, but much coarser than in the microperthitic orthoclases, t
length and breadth being about 0·05 to 0·1 mm. and 0·005 to 0·01 mm. resp
tively. The vein perthite ranges up to about 0·1 mm. in breadth and seve
millimetres in length. The finer lamellae lie mainly along the trace of (100); t
directions taken by the larger lenses are more irregular, often branching off fr
(100) into prism traces.

In the neighbourhood of the coarser vein perthite the finer lamellae tend
be scarce or absent, but here and there, occasional smaller lamellae dive
towards the larger units, rivulet fashion. This coalescence is more pronounc
near the ends of the larger lenses, and can be better observed under polariz

ight with the albite lamellae in extinction and the nicols slightly uncrossed to ubdue the microcline twinning and show up the perthite. A photograph taken vith this setting is shown in pl. VI, fig. 1. The stream-like diversion of the finer amellae towards larger individuals is fairly evident. This segregation appears o have been very sensitive to the influence of slight local movement in the felspar nd to the presence of foreign inclusions. The effect of such inclusions can be seen n pl. VI, fig. 2, which shows three quartz blebs (one to the left of the photograph, ne centre, and a very small one below centre) and a mica lath on the left, all of vhich have acted as nuclei for coalescence of the microperthite. Another feature ommon to these two sections, seen also in microclines from other localities, is he development of a much coarser type of microcline twin blading around the oarser perthite lenses, with a preponderance of the albite over the pericline winning. This may be due to the coarser albite blades having imposed a larger ype of twinning on the common lattice framework of the adjacent microcline, or n part to the absence of fine microperthite in these areas having allowed greater reedom for the microcline to form uninterrupted twin blades.

Sections on (010).—Sections on (010) show the usual longitudinal microperthitic amellae typical of many microclines, running in a direction approximately 73° o the basal cleavage as in microperthitic orthoclase. The length of the individual amellae is about 0·1 mm. and the thickness about 0·01 mm. These dimensions re several times larger than the microperthite commonly seen in orthoclase and he definition is much sharper, indicating a more complete separation from the otash-felspar component.

Here and there one sees coarser bands of vein perthite up to several millimetres n length and 0·1 mm. in thickness. These larger lamellae tend to run obliquely cross the finer microperthite, in a direction roughly 64° to the trace of the basal leavage. Many of them show incomplete segregation, and their formation can e progressively traced from the coalescence of a few microperthitic individuals, heir segregation into a 'swarm', and the coalescence of these into vein perthite. he swarms of smaller aggregates usually show a crude echelon arrangement ol. VI, fig. 3).

Sections containing myrmekite.—In sections on (010) across the quartz-micro- ine junctions, the quartz cuts clean across the perthite texture with no change n size or amount of perthite near the contact, and with no evidence of selective ction on either of the two perthite components. Occasionally, however, the vein erthite may continue as a band or layer of albitic material along the junction. ometimes these films are found along one side only of a quartz rod, or round a promontory, suggesting that they may have filled in cracks or cavities formed at he junction by a slight relative movement of the two components. The films re in crystallographic and optical continuity with the adjacent vein albite amellae and extinguish with them. A section on (010) through one of these oundary films, is shown in pl. VI, fig. 5, with the microcline in extinction. The arker 'core' of the film of albite is due to the slightly lower extinction-angle of he central portion, which is a little more anorthitic than the rest. The quartz rod, en in the lower half of the picture contains two islands of microcline, oriented fferently from the main microcline and from each other. These will be referred later in the text.

In places these boundary films broaden out, when the central core becomes

larger and still more anorthitic, and small rods of quartz make their appearanc Occasionally these boundary films or segregations thicken out into true myrmeki 'warts' or protuberances, with convex surfaces turned towards the microclin and with a core of more anorthitic plagioclases containing the characteristic verm cular quartz of ordinary myrmekite. A number of myrmekite blebs which ha grown out in this way along a quartz-microcline junction are shown in pl. V fig. 6. The section is cut parallel to the (010) direction of the microcline a viewed with the quartz rod and the vein perthite in extinction, the myrmek quartz and the body microcline being in illumination. The myrmekite has 'warty' appearance and texture common to these intergrowths, with conv surface turned towards the microcline. It will be noted that the myrmekite bl have a dark outer rim which is in extinction with the vein perthite and that the join up and blend together in places. They have the same composition and h evidently been formed at the same time. Their extinction-angle is 16° relative the basal cleavage of the microcline, corresponding to the composition $Ab_{94}A$ That of the myrmekitic core is 6°, corresponding to $Ab_{77}An_{23}$. As would expected from this difference in composition the myrmekitic quartz is almo confined to the more anorthitic cores. It will be observed that the change fr albitic rim to anorthitic core is very sharp.

The progressive development of vein perthite by coalescence from micr perthite, and of myrmekite through boundary film albite, indicates that bo these forms of plagioclase were derived from microperthite, and thence original from solid solution in the potash-felspar.

A few sections of the microcline of this graphic rock show crush or 'mush' zon in which myrmekite has developed. One such crush zone, lying between the en of two graphic quartz rods, is seen in pl. VII, fig. 8, in (001) section betwee crossed nicols. Only one of the quartz rods is shown—to the left of the phot graph. The zone contains a few myrmekite blebs associated with a number hypidiomorphic microcline crystals. These have a random orientation relative the main microcline crystal and are bordered in places by a rim of albite. The are more pellucid and less perthitic than the main microcline crystal, indicatin that they have formed later and at a lower temperature, yet within the exsolutio temperature range.

Another interesting (010) section of a crush or 'mush' zone is shown in pl. VI fig. 7, with the body microcline in partial extinction. A portion of the ma microcline crystal embayed in a graphic quartz rod—shown in the upper part the photograph—has been torn away and twisted through an angle of about 30 as can be seen from the relative perthite directions in the two parts. The 'mush zone between them contains myrmekite together with small albite and microcli crystals. The strongly perthitic character of the embayed microcline fragme shows that it was formed at or near the same temperature as the main microcli The absence of sharp fracture lines between the two portions indicates that whe the relative movement occurred the quartz rod was more or less rigid and th body microcline in a semi-plastic or 'mushy' condition. The curvature of th perthite bands towards the crush zone also lends support to this view. Th 'rucking up' of the microcline in this Kodarma rock referred to on p. 80 an shown in text-fig 1, also suggests a greater rigidity of the quartz rods than th microcline during the consolidation period.

3. Similar Textures in Pegmatitic Microclines from other Areas.

While it is possible that the structures described in these Kodarma graphic ecimens, namely coalescence of microperthite into vein perthite and the forma- n of myrmekite blebs, may have been influenced in part by relative local vement between the graphic quartz rods and body microcline, similar features ve been observed in pegmatitic microclines from other areas without accom- nying evidence of local movement.

Incipient coalescence of the microperthite can be seen in the section of dental crocline from Quebec shown in pl. VI, fig. 4. Here coalescence has been en- uraged by the presence of small mica inclusions. This segregation or coalescence often accompanied by other evidence of the close genetic relationship between two forms of perthite, as, for example, the depletion or impoverishment in croperthite of the areas immediately surrounding the larger perthite lenses. VII, fig. 9, shows a (010) section of microcline from a pegmatite near Asansol, ngal, in which the vein perthite lenses, arranged in echelon, have robbed the rounding areas of fine microperthite.

Another feature sometimes seen is the 'patterning' or regular distribution of the er lamellae in relation to the coarse, as is shown in pl. VII, fig. 10, which resents a (010) section of a microcline from the Nellore mica-pegmatites, dras. This feature is usually associated with an irregular arrangement of the n perthite and may indicate local movement during consolidation.

Microperthitic impoverishment, or depletion, near the coarser albite lenses has en recorded by Maurice (1940, p. 166) in pegmatitic microcline from Spruce ne, North Carolina. His view is that the larger perthite or 'veinlets' have been med by recrystallization of the albite squeezed from the nearby microperthite nellae.

In the writer's opinion many of the excellent photographs figured by Andersen 28, pls. I and II) show this coalescence of the microperthite, with consequent pletion near the larger vein perthite. Another example figured by Goldich and nser (1939, p. 418) shows, in a section of pegmatitic microcline from Granite untain, Texas, coarse vein perthite, fine 'patterned' microperthite, and short s of coarse perthite in echelon with depleted areas between.

Microcline perthite sometimes shows incipient myrmekite within the vein thite lenses, especially when the felspar is higher in lime than usual. A section microcline perthite on (010) from a pegmatite near Burakur, Bengal, shows s feature (pl. VII, fig. 11). The single broad band of vein perthite is seen contain darker, more anorthitic cores, within which a few bright rods of myrme- c quartz occur. All the vein perthite in this microcline shows this feature in a ater or less degree. The extinction of the outer shell relative to the basal ıvage, is 18°, corresponding to $Ab_{97}An_3$. That of the core averages 9–10°, responding to $Ab_{88}An_{12}$.

ndersen (1928, pp. 155–162) also noted more anorthitic cores in many of the ı perthites examined by him and of one specimen he remarked 'a charac- stic of this specimen as of many others, is that the veins always contain fairly ılarly arranged bodies of quartz running along the central part of the vein'. th (1928, pp. 424–428) has described in some detail incipient myrmekite tures in vein perthites of pegmatitic microcline from primitive rocks in

southern Norway, very similar to the one shown on pl. VII, fig. 11. He measu the extinction-angles of the shell and the core in 18 specimens, 16 of w averaged $Ab_{95\cdot4}An_{4\cdot6}$ for the shell, and $Ab_{87}An_{13}$ for the core. He observed t the composition of the shell was the same as that of the microperthitic al lamellae, and he suggested that both the fine and the coarse perthite had b formed by exsolution, the lime-felspar separating first—with some of the soc at a higher temperature, followed at a lower temperature by the bulk of the s felspar which had deposited as shells round the earlier lime-soda-felspa separately in the body microcline as microperthite. Shibata (1933) has figu true wart-like myrmekite in a peculiar pegmatitic microcline-perthite fr Ishikawa.

4. Origin of these Textures.

In the foregoing pages, three well-known rock textures, namely graphic quar microcline, vein and microperthite, and myrmekite, have been describe association in the same pegmatite rock, and observations and deductions h been made in regard to their origin. Each of these textures has, in the pa formed the subject of investigation and research by petrographers and a co siderable volume of somewhat controversial literature is now available in rega to them. In order to discuss the relevance of the observations made in these pa to the various theories which have been put forward to account for the formati of these various textures, a brief résumé will be made of the literature deali with each type.

(*a*) *Graphic granite.*

Because of the resemblance to many artificial eutectic crystallizations and t relatively constant ratio of quartz to felspar, these graphic intergrowths we early ascribed to simultaneous crystallization of the eutectic kind by Vogt (190 Mäkinen (1917) measured the ratio of quartz to felspar in a number of grapb granites of Finland and found a limited free-quartz range of 23–32 %. Holm (1919, p. 77) carried out field measurements on a number of graphic gran exposures in Mozambique and obtained a quartz range of 24–28 %. In both the cases the results were believed to support the direct crystallization theo Eskola (1928), examining the rapakivi rocks from the Gulf of Bothnia, fou micrographic quartz-felspar growths around orthoclase cores. One of his figur shows them growing out perpendicularly from each face of an idiomorphic felsp crystal, proving in this case an origin by simultaneous crystallization. Fersm (1929) examined the relative orientation of the quartz rods and the felspar a found a definite relation between them. He also noted that in some cases t quartz rods were of the 'high' temperature kind, in others the 'low'. His co clusions were that the texture had been produced by simultaneous crystallizati of the quartz and felspar. Vogt (1931, p. 125) in a later discussion of granites a granite-pegmatites, suggested that graphic granite had been formed by simu taneous crystallization from a 'cotectic' magma, at a late stage in the consolid tion of the pegmatite. He assumed the composition of the cotectic magma to l the same as that of the graphic granite, plus a third component consisting $SiO_2.nH_2O$, and a small amount of other mineralizers. Vogt again emphasiz that these intergrowths fell within narrow limits of composition, both as regar

ıe quartz-felspar ratio and the ratio of potash- to soda-felspar, the latter being ɔout the same as that in ordinary pegmatitic microclines.

Other investigators have questioned the limited range of composition ascribed ɔ these graphic granites and have expressed the opinion that many, if not all of ıem, may have been formed by the replacement of potash- or potash-soda-lspar by silica. Schaller (1925, pp. 274–276) suggested that the original peg-ıatite rock possibly consisted of orthoclase and that this had been successively ɔlaced by soda and by silica-bearing solutions. He observed (1927) that the ıartz rods of the graphic structures cut across the perthite lamellae and ıbmitted this as evidence that the quartz had been introduced after the forma-on of the perthite. Vogt (1931, p. 136), however, suggested that as the perthite mellae had been formed by exsolution, they had naturally stopped at the ıartz rods, hence the appearance of their being 'cut across' by the latter. andes (1932) discussing the origin of the graphic granite of Baringer Hill, Texas, ferred to Vogt's observations and pointed out that in the Baringer Hill pegma-te the quartz rods cut across 'vein' perthite which, according to Andersen (1928) ıd Alling (1932), is a product of replacement and not of exsolution. Hence he ɔncluded that the graphic quartz must have been introduced by replacement at still later stage than the vein perthite. In support of this view he instanced ıe occurrence of 'islands' of microcline within the quartz rods, having the same ientation as the main microcline crystal. Hess (1933, pp. 451–452) referring to ıe Minor Keith pegmatites near Auburn, Maine, remarked: 'the production of aphic granite from a perthitic feldspar dike by the introduction of quartz from ıartz veins is almost diagrammatically shown'. Wahlstrom (1939) examined .e relative orientation of the quartz rods and the microcline in a number of aphic granites and obtained results at variance with those of Fersman. He also ıestioned whether these structures had a limited range of composition and con-uded that they had been formed, in the main, by replacement and not by nultaneous crystallization. Switzer (1938, 1939) and Mitchell (1941) may be entioned as recent investigators who have favoured the idea of simultaneous ystallization for these graphic granites. Uspensky (1943) described a peculiar diating type of graphic granite in a pegmatite of Transbaikal, which displayed rhythmic broadening and narrowing of the quartz rods, and which he believed d been produced by simultaneous crystallization. In an earlier paper (1938, ɔ. 105–106) the writer refers to these graphic granite textures, citing five Indian mples with a limited compositional range, and concludes that the constituents ve crystallized simultaneously.

The arguments for and against simultaneous crystallization on the one hand d replacement on the other, have thus centred round:

(1) *Quartz-felspar ratio.*—A few workers have questioned the limited composi-ɔnal range, but the great majority of those who have examined the quantitative ationship between the quartz and the microcline have concluded that the mpositional range is a comparatively narrow one—far too narrow to be plained by replacement.

A feature sometimes met with in these graphic quartz-microcline structures, ıich has a bearing on this compositional range, is the local impoverishment of ɛ surrounding area by a larger quartz rod or 'ichthyoglypt'. Text-fig. 2 shows ıand-specimen of graphic quartz-microcline with a central larger rod which has

evidently robbed the surrounding area of free silica. Another specimen with fin grained graphic structure is shown in text-fig. 3; the relatively larger rods s seen to be surrounded by areas devoid of quartz. This feature of impoverishme already discussed in relation to the perthites, is more common in the lat probably owing to the greater mobility of the alkali ion than the silicon-oxy

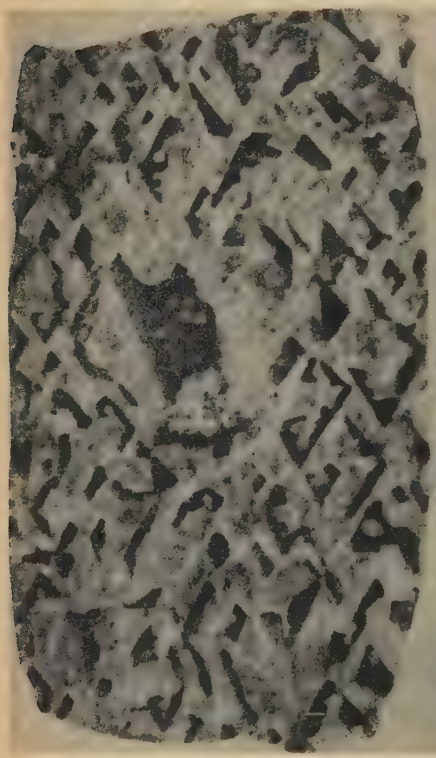


Fig. 2. Graphic granite, Jointora, Bihar, India. Ground on (100), showing local impoverishment in quartz. ×2·5.

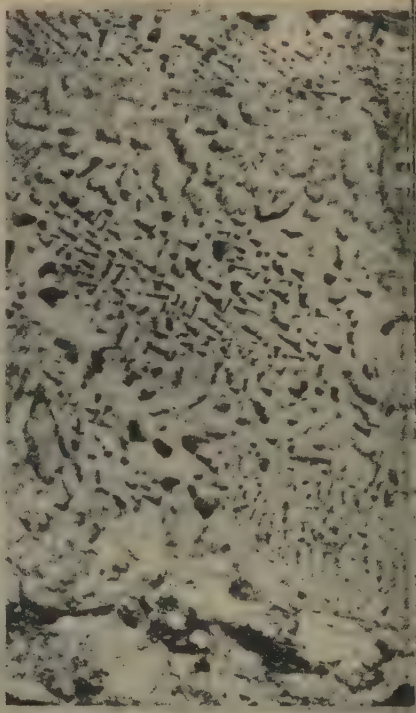


Fig. 3. Fine-grained graphic granite fro Miask, Urals. Ground on (100), mainl Shows local impoverishment in quartz. ×

group. Similar impoverishment or depletion of the surrounding areas in foc supply by larger individuals is a common feature of metallic alloys, and can b produced almost at will either by direct crystallization or by exsolution from th solid state. Where such impoverishment occurs in these rock textures, it provid strong evidence of simultaneous crystallization rather than replacement.

(2) *Crystallographic relationship.*—Whether such a relationship exists betwee the quartz rods and the microcline is still an open question which may yet b solved by X-ray analysis. Oriented intergrowths like the one figured by Esko (1928, pl. I, fig. 3) or the coarser rhythmic intergrowths described and figured b Uspensky (1943, p. 439) would, however, be difficult to explain by replacemen

(3) *Relationship of quartz to the perthite.*—The 'cutting across' of the perthit by the quartz, put forward by Schaller as evidence of replacement, appears to th

riter to be of doubtful value. One would expect such invading silica-bearing olutions to have dissolved away more of one perthite component than the other, they were already in existence when the silica was introduced, yet there is no vidence at all of selective action. This is all the more remarkable when it is emembered that the silica-enrichment phase is assumed to have followed replace-ient of potash- by soda-felspar to produce vein perthite. Equally remarkable—they are replacements—is the manner in which the silica-bearing solutions have voided earlier perthite replacement directions and other 'lines of weakness' in ie felspar.

The Kodarma specimens described in the foregoing pages, provide direct evi-ence that the appearance of 'cutting across' by the quartz rods of the perthite oes not necessarily imply a later origin for the quartz. In the same section—as pl. VI, fig. 5—one can observe the quartz cutting clean across the perthite, hilst a short distance away a layer of albite lies along the quartz rod boundary. hese albitic layers have most obviously been deposited against the quartz, and if iey and the vein perthite are of the same age, the quartz must antedate both. his view is also supported by the occasional presence, in graphic-granite sections, vein perthite partially enveloping or wrapping round the end of a quartz rod. he two sections figured by Wahlstrom (1939, p. 691) show this phenomenon.

In other specimens, where the graphic structures are sufficiently small for veral parallel quartz rods to be observed in the same section, the true relation-ip is seen to be one of perthite growing out from the quartz rods, not of the uartz cutting the perthite. This is shown in pl. VII, fig. 12, which represents a ction of fine-grained graphic granite from the Urals, cut along the basal plane id seen under crossed nicols with the body microcline in the 'neutral' position. he vertical white bands are quartz rods; the nearly horizontal torch-like blades e vein albite. It is very evident that the latter have, in the main, grown out om the quartz rods and not been cut across by them. Another feature met with these graphic structures and which suggests simultaneous crystallization, is the dden change in size or direction of the quartz rod 'ichthyoglypts' within the me microcline crystal, as can be seen in text-figs. 4 (*a*), (*b*), and (*c*), which show ree views of a specimen of quartz-amazonite graphic rock from the Urals. The icrocline is one untwinned crystal, and from an uneven surface within the ystal—lying near an orthodome—the quartz rods have grown out in two rections and sizes. The fine white striations nearly perpendicular to the trace (001) in the upper portion of fig. 4 (*a*) represent vein perthite.

The 'rucking up' of the microcline described on p. 80 and illustrated by xt-fig. 1, also suggests that the consolidation of the body microcline took place er that of the quartz rods. So also does the torn fragment of microcline em-yed in a quartz rod referred to on p. 82 and shown in pl. VII, fig. 7. Landes's ggestion, already mentioned, that 'islands' or patches of microcline, lying thin the quartz rods and oriented with the main microcline crystal, represent placement residues loses its value if it can be shown that these 'islands' often ve 'random' orientation. Of the many such inclusions observed by the writer the Kodarma graphic granite probably less than half show parallel orientation. ie two seen in the lower part of pl. VI, fig. 5, both have 'random' orientation. ith 'islands' of random orientation the evidence is definitely against replace-ent; with those showing parallel orientation one is never certain that the

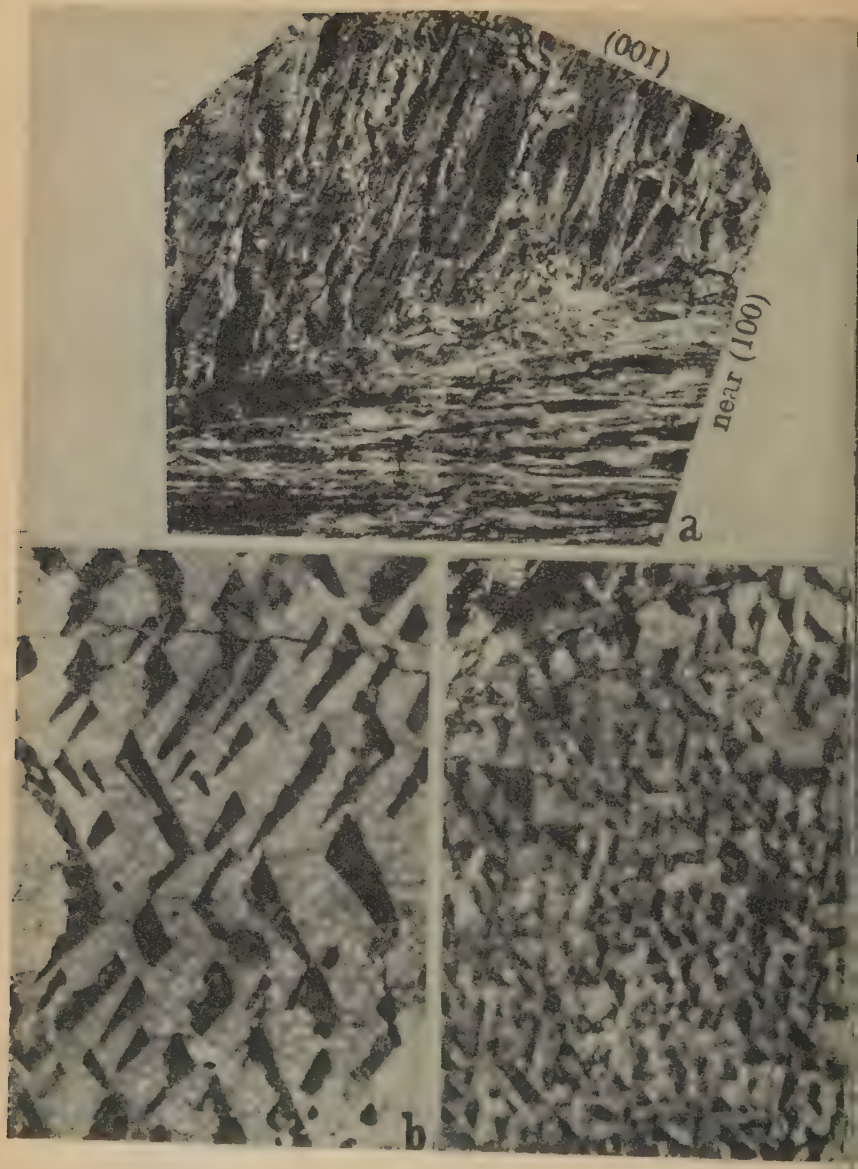


FIG. 4. Graphic quartz and amazonite from Miask, Urals. (*a*) Roughly cleaved on (01 Shows two directions and sizes of quartz rods in the same microcline crystal. The fi striations in the upper part are vein perthite. $\times\frac{2}{3}$. (*b*) Ground on (001). $\times 1{\cdot}5$. (*c*) Grou on surface near (100). $\times 1{\cdot}5$.

paration of the inclusion from the body microcline is absolute, or only apparently so, due to the particular direction of the section.

(*b*) *Vein perthite and microperthite.*

It is now generally agreed that the microperthite commonly found in potash-da-orthoclase and to a lesser degree in microcline has been formed, as originally ggested by Vogt (1906), by an 'unmixing' of the potash- and the soda-felspar which process Alling (1921, p. 222) gave the name 'exsolution'. The writer has own (1930, 1937) that these microperthitic lamellae can be taken into solution heating and brought out again on slow cooling at temperatures far below the elting-point of the felspar. X-ray investigations by Taylor and others (1934) ve provided an explanation of these changes based on the migration of the kali ions within a relatively rigid SiO_4AlO_4 tetrahedral framework.

Microperthite is best developed in the orthoclase felspars; in the microclines, e coarser form, vein perthite, usually predominates. Andersen (1928) has plained the formation of this coarser type of perthite on the assumption that rinkage cracks were developed along certain directions in the felspar, whilst oling from its formation temperature (near 850° C.) down to the quartz inver-on temperature of 575° C. Soda-bearing solutions had then entered these cracks d formed vein perthite. In a previous issue of this magazine (1938, pp. 106–107) e writer has expressed the opinion that much of the evidence available in regard these potash-soda-felspars is at variance with Andersen's shrinkage crack theory. ne additional information supplied by these Kodarma and other Indian speci-ens lends further support to this view. They show that the vein perthite has en formed by a process of exsolution and coalescence while the felspar was obably in a semi-plastic state. In this condition the formation of shrinkage acks would not be possible. Moreover, these microclines have probably been rmed not very appreciably above the lower limit of Andersen's temperature nge. On the other hand, the microperthitic orthoclases formed in all probability arer the upper limit of this range are signally devoid of vein perthite.

It is possible that the differential contraction of orthoclase felspar with falling mperature may have had an effect on the *microperthitic* separation or exsolution, the *opposite* manner to that suggested by Andersen. X-ray investigations dicate that the greater expansion and contraction along the *a*-axis with change temperature is caused by a concertina-like extension or closing up of the linked trahedral chains of the felspar framework along this direction. Such a closing of the chains with falling temperature would have the effect of internal com-ession rather than tension in that direction, and the separation of the micro-rthitic albite lamellae perpendicular to this direction would be analogous to e orientation of mineral plates or films in a slate or schist, perpendicular to the rection of pressure.

Schaller (1925, p. 276) suggested that the physical changes resulting from the version of orthoclase to microcline in pegmatites, may have facilitated the trance of albitizing solutions. An accurate comparison of the densities of these o felspars is difficult, owing to the heterogeneous character of most microclines, t from a number of analyses and density determinations made by the writer, gether with similar determinations made by Jayaraman (1940) on microclines, stimate that the difference in density between orthoclase and microcline—of

the same chemical composition—is in the order of 0·004, with microcline t heavier. This corresponds to a difference in volume of about 0·16 % which is o about one-quarter of the volume change caused by the exsolution of 25–30 % microperthitic albite (Spencer, 1937, p. 470) and only about one-tenth the to volume change on slowly cooling such a felspar from 750° C. to 450° C. (Kôz 1925). Hence, even if such an inversion has taken place fairly rapidly, it co not have had any pronounced effect on the physical conditions within the cool felspar. It is more probable that the principal effect would be to reduce the so solubility of the soda- in the potash-felspar.

Vogt appears to have regarded both vein perthite and microperthite as produc of exsolution and Barth (1928) regarded the Norwegian perthites in this lig Shaub (1929, p. 76) has also suggested that the vein type of perthite may h been formed by exsolution. The modern concept of microperthitic exsolutio representing a metallic ion, and not a complex molecular translation within c solid crystal, lends itself to the suggestion that these larger lamellae may h been formed in this way. Nevertheless the fact, already emphasized, that potash-soda-orthoclases, formed at higher temperatures than the microcline contain only fine microperthite does indicate that these ionic segregations in t solid felspar produce only the fine variety of perthite.

What then are the conditions under which the pegmatitic microclines, wi their varied types of vein and microperthite, have been formed? Heat-treatme experiments by the writer (1937, p. 473) on the microperthitic orthoclases ha shown that up to 30 % of soda component can be taken into solid solution, b heating for relatively short periods to about 750° C., and brought out again b slow cooling to 400–450° C. This 'main exsolution temperature range' is co siderably below the formation temperatures of the orthoclase felspars. On t other hand, field and other evidence indicates that the microclines have probab crystallized somewhere between 500° C. and 700° C., which temperatures fa within the above exsolution range. *In the writer's opinion it is this overlap of t crystallizing temperatures into the 'main exsolution temperature range' which h given rise to the differences in texture and character between the microclines and t orthoclases.*

Let us assume potash-soda-felspar to be crystallizing from a pegmatitic magm at a temperature of say 700° C., saturated with soda component at that tempera ture (25–30 % soda component), and with the magma rich in water and othe mineralizers. If, due to rapid cooling or the sudden loss of liquefying mineralizer solidification is rapid, a felspar approaching orthoclase in character would b formed, with fine and fairly regular microperthite, fine woolly cross-hatch twinnin —so fine as to be nearly invisible—and devoid of vein perthite. Microclines of thi type are not uncommon, and have occasionally been obtained by the writer fro narrow bands of pegmatite where field evidence of rapid cooling is found. The are often richer in soda than those containing vein perthite.

The texture of a microcline formed under the above conditions, would b modified if the crystallizing period was prolonged, or if, after solidification, th felspar had been subjected through the exsolution temperature range to th soaking action of residual magmatic liquids held within the pegmatite. By suc means the formation of larger perthite individuals by coalescence would b induced, leaving the adjacent areas impoverished in microperthite.

Very slow cooling in the presence of mineralizers would allow additional factors come into play. Exsolution would accompany crystallization and the local rains set up thereby in the crystallizing lattice framework would encourage version to the microcline form, causing increased exsolution. The falling mperature would also reduce the solubility for soda in the magma and in the ystallizing felspar and the excess would tend to crystallize independently within e felspar meshwork as coarser vein perthite less regular in type than that formed coalescence. Magmas crystallizing at lower temperatures would produce icroclines lower in soda and with less perthite.

This brief attempt to explain the origin of the various microcline textures, rmed in ordinary granite-pegmatites by direct crystallization from a more or ss 'closed' magmatic system, takes into consideration the fact that by far the eater majority of these microclines contain no more—and often no less—soda mponent than one would expect from equilibrium conditions at their probable rmation temperatures. Thus the introduction of soda, by way of albitization replacement from without, is quite unnecessary to account either for the com-sition, or for the different perthite textures found in these microclines.

I would here emphasize, however, that the foregoing observations regarding placement in pegmatites, refer only to the ordinary or simple granite-pegmatites which microcline and quartz are the principal constituents, muscovite and free agioclase, &c., being present only in subordinate amounts. The complex gmatites, on the other hand, are usually richer in plagioclase and often show dubitable evidence of replacement by soda-bearing solutions in the form of lics or remnants of older pegmatitic material partly or wholly enclosed within e invading felspar. Owing to their economic importance as repositories of many re or valuable minerals these complex pegmatites have received much more tention from the mining geologist and mineralogist than the simple granite-gmatites. Nevertheless, this should not blind one to the fact that they represent ly a very small fraction of the total volume of pegmatitic material, and con-usions drawn from them, in regard to replacement, cannot be applied in a general y to ordinary pegmatites, without checks as to their validity. Even the mplex pegmatites have occasionally been referred to a direct crystallization gin. For example Shaub (1940) examined a number of the lithium-bearing gmatites of Maine and expressed the opinion that their texture and mineral semblage could be best explained by direct crystallization from a closed gmatic system. Maurice (1940) has attributed the origin of the mica-bearing goclase-pegmatites of the Spruce Pine district, North Carolina, mainly to direct ystallization.

(c) *Myrmekite.*

Few microscopic rock intergrowths have received so much attention, or been e subject of so much controversy, as the wart-like assemblages of plagioclase d vermicular quartz to which Sederholm (1897) gave the name 'myrmekite'. ese intergrowths are found in granites, granite-gneisses, charnockites, syenites, d in most deep-seated rocks in which potash-soda-felspar plays a prominent e.

Becke (1908), who made the first systematic examination of myrmekite, owed that it consisted of quartz and plagioclase felspar, the proportion of

quartz to felspar increasing with the basicity of the plagioclase. He also observ that the basicity of the myrmekitic plagioclase increased with that of the prim plagioclase of the rock. He found that in most cases the myrmekite grew from a central core or kernel of quartz-free plagioclase invasively into adjace orthoclase or microcline, the convex surface of the myrmekite projecting i the potash-felspar. He suggested that these facts could be best explained the assumption that the potassium of the orthoclase or microcline had be replaced by sodium and calcium. The sodium would be exchanged atom f atom with the potassium yielding an equivalent of albite; but, with calci anorthite would be formed in place of potash-felspar, and this would rel the equivalent of four molecules of silica, hence the quartz of the myrmek the more basic the plagioclase the greater the quantity of quartz. He fur suggested that the potash set free by this transformation might have gi rise to the secondary muscovite commonly found in rocks rich in myrmekit

Schwantke (1909) discussing the role of the lime-felspar held in solid solu in potash-soda-felspar, found that most of the then available analyses sho an excess of silica over that required by the felspars, and a deficiency of to felspars from 100 %. By recasting the lime-felspar as $Ca(AlSi_3O_8)_2$—analog to orthoclase and albite—in place of anorthite $CaAl_2Si_2O_8$, he found that for majority of the analyses the discrepancy largely disappeared. He pointed that if the lime was really present in solid solution in this higher silicate for it would account for the quartz in the myrmekitic intergrowths. The lime-felsp would, on separation from solid solution, revert to the anorthite form, setti free the equivalent of four molecules of silica. Schwantke appears to ha abandoned his hypothesis because 'the observations on perthitic felspars do show a release of free silica during exsolution', but he concluded 'However, t observed facts and possibilities merit careful study. Above all, with new analys on pure suitable material, the role of Ca in the potash-felspars could be mo accurately determined.'

Petrologists who have suggested a direct crystallization origin for myrmekit on the lines of micropegmatite formation, include Petrascheck (1904), Tschi winsky (1911), Sustschinsky (1912), and Svitalsky (1913). Luczizky (191 considered myrmekite to be of secondary origin, but suggested that its formati was closely bound up with the alteration and dissolution of primary isomorpho mixtures of potash-sodium-lime-felspars.

Eskola (1914, pp. 27–28) discussing the myrmekite occurrences in the micr cline-granites of south-west Finland referred to the frequent occurrence myrmekite with rectilinear boundaries against the microcline. These idiomorph forms occurred associated with ordinary curved myrmekite, having been form later than the rectilinear variety. Eskola agreed with Becke that myrmek had been formed towards the end of the period of rock consolidation, but su gested that the idiomorphic form originated earlier during the process of co solidation.

Sederholm (1916) made an extensive survey of the literature on myrmekit and myrmekite-like intergrowths, adding his own detailed observations o myrmekite in rocks from Fenno-Scandia. He considered that these intergrowt 'cannot be regarded as primary in the strictest sense of the word since the have crystallized within the borders of another mineral, replacing its substance

e stated, however, that in many cases the structures were formed 'before the al consolidation of all the mineral constituents of the magma in question. e greatest part of the magma itself had crystallized, but solutions and ses, derived from the neighbourhood or from more distant parts of the ne rock masses, still circulated within them.' With Becke, he concluded that rmekite has been produced by the replacement of the potash in orthoclase or crocline by soda and lime from late-stage magmatic solutions, silica being free by the lime in the process. For changes of this nature in direct con- uation of the consolidation of the rock magma, Sederholm proposed the m 'deuteric'.

Myrmekite intergrowths examined by the writer, in British granites and in nites and charnockites of Indian origin, show, in general, a convex surface vasive' into the potash-felspar, as described by Becke and Sederholm. In ne cases, however, more particularly in the Indian charnockites rich in rmekite, the tendency towards rectilinear outlines described by Eskola is served. In these rocks also, blebs of myrmekite totally enclosed in microcline orthoclase are not at all uncommon. The potash-felspar is sometimes ortho- se, sometimes microcline and is almost invariably perthitic.

If we examine the evidence put forward by Becke, Sederholm, and others for e view that these intergrowths have been formed by secondary replacement— iew which has been accepted and used by many petrographers as evidence of itization in these rocks—we find that it rests almost entirely on the appearance 'invasion' which the myrmekite assemblage presents towards the potash- spar. Other features including type of intergrowth, relation of amount of artz to the basicity of the plagioclase felspar, and the decrease of basicity vards the outside of the intergrowths, can be as readily explained by direct stallization or other methods of formation, while the tendency to rectilinear lines sometimes seen in these structures suggests (as intimated by Eskola) ect crystallization rather than replacement. Where the myrmekite occurs ally enclosed in potash-felspar—or in plagioclase as instanced by Sederholm he replacement theory needs to assume connecting channels for the invading utions, or a reconstitution of the enclosing felspar, for which there is often le or no evidence.

Perhaps the strongest objection to the replacement explanation of these ergrowths, in other words to albitization, lies in the strictly limited size of se structures and the limited amount of local 'replacement' which they resent. As Sederholm has pointed out, these myrmekite structures never eed about a millimetre in diameter yet they usually occur scattered fairly nly through very large rock masses, without completely 'replacing' the ash-felspar present, even in the small localized area of a hand-specimen. is itself points to a *very* local source for the 'invading' plagioclase and to closed system'. Sederholm (1916, p. 136) gives one instance of a porphyritic nite in which the amount of myrmekite is as high as 15 %. A granite of s type would probably contain, originally, as much as 50 % potash-soda- par, so that even with 15 % of myrmekite there would still be more than half potash-soda-felspar 'unreplaced'.

s it possible then that this 'invasive' character of the myrmekite into the ash- or potash-soda-felspar is only apparent and that it does not truly

represent 'replacement' by solutions rich in soda and lime from outside sourc
The pegmatitic myrmekites described in the earlier part of this paper, sh
that true wart-like myrmekite can be formed, along with vein perthite, by
process of exsolution, coalescence, and segregation, from material held at
time in solid solution within the crystallizing potash-felspar, or in part li
within its interstices. Moreover, the quartz of the myrmekite has also
doubtedly come from the same local source as the plagioclase, and as the am
of quartz varies directly with the basicity of the plagioclase, we are driven
the conclusion that there may be some truth in Schwantke's hypothesis
high silica-lime-felspar for that portion held in solid solution in potash-felsp
The transformation of this silicate $Ca(AlSi_3O_8)_2$ to anorthite $CaAl_2Si_2O_8$
exsolution, would provide the quartz of the myrmekite.

Do recent analyses of potash-soda-felspar throw any more light on t
problem than they did when Schwantke made his observations? Most analy
examined by the writer show a definite excess of silica and a deficiency of
felspars when the anorthite formula is used in felspar calculations. The fel
deficiency is often hidden in published analyses by the practice—of which t
writer has himself been guilty—of recasting the results to 100 %. The d
crepancies are not regularly proportional to the lime contents, but they te
to disappear in lime-free potash-soda-felspars. Usually the relatively low li
contents of these felspars, together with possible errors of analysis, render
comparison between the two formulae inconclusive, but it can be said that
most cases the high silica formula would agree with the ultimate analysis
least as well as the anorthite formula. It is conceivable that both forms m
be present in potash-soda-felspar.

X-ray interpretations of potash-soda-felspar structures also involve the pa
played by the lime-felspar held in solid solution. Are the calcium ions int
changeable with sodium and potassium ions in a relatively rigid SiO_4Al
tetrahedral framework with the same monoclinic setting and environment,
does each calcium ion have the unique triclinic setting of anorthite? In t
latter case one would expect less freedom to segregate within the framewo
Perthite separations show that the lime-felspar has segregated with the sod
felspar in the early stages of exsolution. Hence the probability that it exists
the homogeneous potash-soda-felspar mainly in the high silica form.

The decreasing basicity from core to rim of myrmekite intergrowths, diffic
to explain by the replacement theory, is readily understood if the lime-felsp
has been derived by exsolution from the potash-felspar. Its early separation
relatively greater portion than the albite would leave the later-formed plagiocla
richer in soda.

Another feature, observed by Becke and other workers, is the more ac
character of the plagioclase of the myrmekite, than the primary plagioclase
the rock. This again would follow from the relatively lower solubility of lim
than of soda in the potash-felspar. The microcline-pegmatites show a simil
relationship between the perthitic plagioclase of the microcline and the prima
plagioclase of the pegmatite. This may be illustrated by the Kodarma and t
Burakur microclines, both of which occur associated with primary pegmatit
oligoclase. Samples of these and of the microcline were analysed with th
following results.

	Kodarma graphic microcline with myrmekite.	Kodarma oligoclase.	Burakur microcline with myrmekitic vein perthite.	Burakur oligoclase.
O_2	64·56	66·52	64·46	63·2
O_3	19·25	21·27	18·90	22·84
$_2O_3$	0·35	0·19	0·22	0·32
O	trace	trace	trace	trace
O	0·22	1·95	0·27	3·36
$_2O$	1·88	9·76	2·10	8·24
O	13·32	0·74	13·63	0·88
n. loss	0·36	0·20	0·20	0·70
	99·94	100·63	99·78	99·54
... ...	15·84	82·5	17·75	69·7
... .	1·10	9·75	1·35	16·8
... ...	75·72	3·2	80·56	2·6
ca	4·0	2·2	—	5·0

In the Kodarma microcline the An : Ab ratio is 7 : 93 and in the oligoclase ·5 to 89·5. In the Burakur microcline the An : Ab ratio is again 7 : 93, but in e corresponding oligoclase it is 19·5 to 80·5. Shibata also found a similar ationship in the Ishikawa pegmatite referred to on page 84. For the myrmekite-aring microcline-perthite the An : Ab ratio is 8 : 92, in the vein perthite lamellae is 14 : 86, and in the primary plagioclase 30 : 70. The high An : Ab ratio in the st corresponds with an unusually high soda-lime content in the microcline 7 %). The microcline is also unusual in containing blue schillerized orthoclase-e patches with reduced optic axial angle. All these features point to a relatively gh formation temperature.

The low An : Ab ratios of most pegmatitic microclines—due to the low tem-rature of formation—would account for the scarcity of myrmekite in them as mpared with deep-seated rocks formed within the exsolution temperature nge. In the above myrmekitic microclines the An : Ab ratio of 7 : 93 is not gh, yet it appears to be higher than the normal value. Andersen's 28 microcline alyses all show a distinctly lower ratio, and although he reported anorthitic cores the vein perthite—with quartz in some cases—none was described as myr-ekitic. Jarayaman (1940) gives 9 microcline and 2 primary plagioclase analyses om Nellore pegmatites all with An : Ab ratios not exceeding 4 : 96. No anorthitic res or myrmekite were reported by him.

Many deep-seated rocks, as for example the soda-syenites, are rich in potash-da-felspar with a fairly high An : Ab ratio, yet contain no myrmekite. This uld be explained by a scarcity of mineralizing solutions in the crystallizing agma. Such relatively dry magmas would become solid well above the main solution temperature range, and true microperthites devoid of myrmekite uld be formed in the same way that high-temperature pegmatites give rise microperthitic felspars devoid of vein perthite. It is significant that in both ese cases the potash-soda-felspar is orthoclase.

Water and other mineralizers would lower the crystallization temperature til it fell within the exsolution range. The conditions would then favour alescence of the soda-lime component separating by exsolution from the tash-felspar. Such segregations might form myrmekite intergrowths within e crystallizing potash-soda-felspar or alternatively collect into blebs, finally crystallize out from solution as myrmekite. The coarser perthites of plutonic

rocks, which have sometimes been regarded as products of albitization, co also be explained in a like manner by exsolution and coalescence. Thus 'injection' perthite of Colony (1923) and the 'deuteric' and other plut perthites figured by Alling (1938) would belong to this type. In many respe they resemble vein perthite.

5. Summary and Conclusions.

The view, that myrmekite, the coarser perthite of plutonic rocks, and vein perthite of pegmatitic microcline, are not the result of albitizatio replacement by solutions from without, but of exsolution and rearrangeme under special conditions, of material formerly held in solid solution in potash-felspar, appears to the writer to agree with the known facts be than any of the various replacement theories. It avoids the *deus ex mac* of invading soda-lime bearing solutions, brought in to act always selective and yet only partially—on the potash-felspar. It also conforms with t experimental evidence that potash-felspar crystallizing out from a magma which soda and lime are present will hold in solid solution an amount of plag clase corresponding to its formation temperature (e.g. 25–30 % at 750° C which plagioclase must of necessity separate from the potash-felspar as mi perthite, or in the coarser form of vein perthite (or myrmekite), by the ti the rock temperature has fallen to 400° C. Evidence has also been provided th graphic granite is a product of direct crystallization and not of replacement.

Thanks are due to Professor P. G. H. Boswell, Professor H. H. Read, a Dr. David Williams for valuable advice and criticism, and to Mr. W. H. Johns for his skilful aid in photography.

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Explanation of Plates VI and VII.

All the figures shown on the two plates represent sections—wholly or in part—of graphic
pegmatite microcline cut parallel to (001) or (010). Sections on (001) are shown with the *a*-a
approximately vertical, those on (010) with the *c*-axis approximately vertical. All, except t
first two, are shown with the nicols crossed. Figs. 1 and 2 are seen with the nicols about 10° o
crossed and the perthite in extinction to subdue the microcline twinning and show up the pert

Fig. 1. Section on (001) of microcline from the Kodarma graphic granite. To show coalesc
of microperthite into vein perthite. Note the coarser microcline twin-lamellae near t
coarser perthite. ×21.

Fig. 2. Another (001) section of the same microcline with same microscope setting. Sho
coalescence of the microperthite towards quartz and mica inclusions. Note the sa
broader twinning near the coarser perthite. ×24.

Fig. 3. Section of the same microcline cut parallel to (010) and with the microcline in extin
tion. Shows coalescence of microperthite albite lamellae into larger units with
echelon tendency. ×21.

Fig. 4. Section on (010) of dental microcline, Quebec, with microcline in extinction. Sho
incipient coalescence of microperthitic albite lamellae into coarser units, especia
near the small mica inclusions. ×21.

Fig. 5. Section on (010) across a quartz-microcline junction, in the Kodarma graphic granit
with the microcline in extinction. Shows segregation of the perthitic albite along th
quartz-microcline contact. The quartz rod contains two inclusions of microcline wi
'random' orientation, one in conjunction with a mica lath which is in extinction. ×2

Fig. 6. Another (010) section across a quartz-microcline junction in the same rock. Sho
segregation of the perthite material into myrmekite along the quartz-microcline junctio
The perthite albite and the quartz rod are seen in extinction, the microcline and th
myrmekitic wormy quartz being illuminated. Note how the myrmekite 'grows ou
from the quartz rod into the body microcline; also the blending of the vein perthi
with the outer myrmekite rims and their common extinction. ×21.

Fig. 7. Another (010) section across a quartz-microcline junction in the Kodarma graph
granite. Shows an embayed portion of the main microcline which has been torn awa
and twisted through an angle of about 30° with no rupture of the quartz rod. Th
mush zone between the two portions of microcline contains small microcline and albi
grains, and myrmekite. ×21.

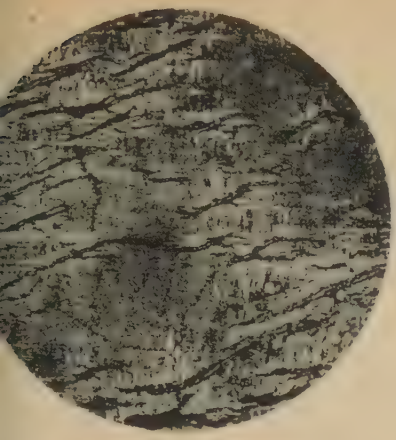
Fig. 8. Section on (001) across a crush zone between the ends of two quartz rods, Kodarm
graphic granite. One of the rods can be seen to the left of the photograph. The crus
zone contains small hypidiomorphic microcline crystals with 'random' orientation, an
some myrmekite. ×21.

Fig. 9. Section on (010) of pegmatitic microcline from Asansol, Bengal, with microcline
extinction. Shows vein perthite lenses in echelon surrounded by dark areas depleted
microperthite. ×28.

Fig. 10. Section on (010) of pegmatitic microcline from Nellore, Madras, with microcline
extinction. Shows 'patterning' of the microperthite in relation to the vein perthite an
some dark areas of 'impoverishment'. ×28.

Fig. 11. Section on (010) of pegmatitic microcline from Burakur, Bengal, with microcli
in extinction. Shows vein perthite containing more anorthitic centres of a myrmekit
character. These are seen as darker patches owing to lower extinction. Note the worm
quartz within them. ×24.

Fig. 12. Section on (001) of fine-grained graphic granite from Miask, Urals. Shows quar
rods (vertical) and vein perthite (horizontal) both illuminated, the microcline being ne
extinction. Note how the torch-like vein perthite grows out from the quartz rods. ×1



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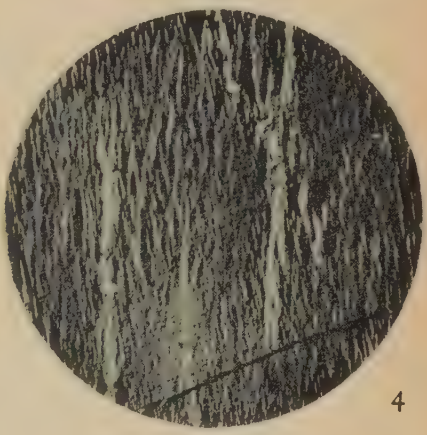

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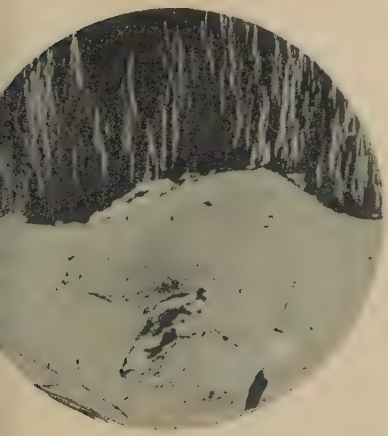

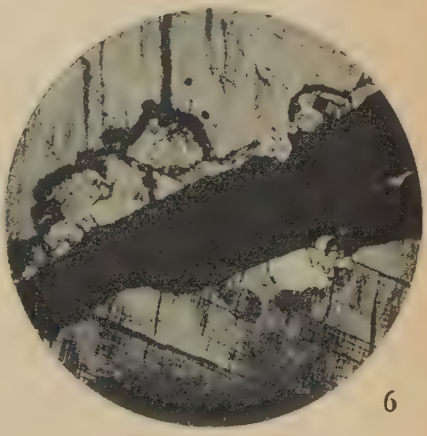

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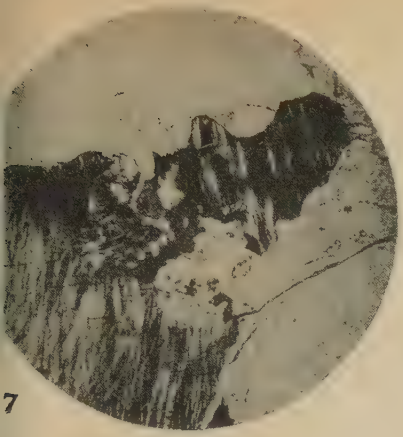

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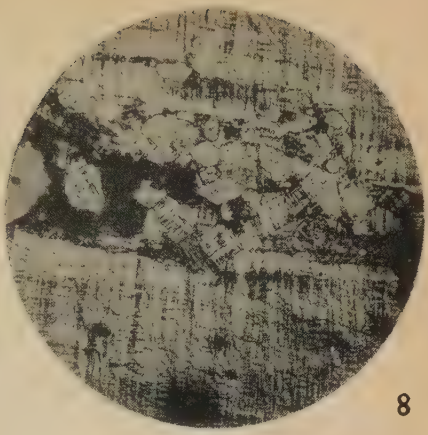

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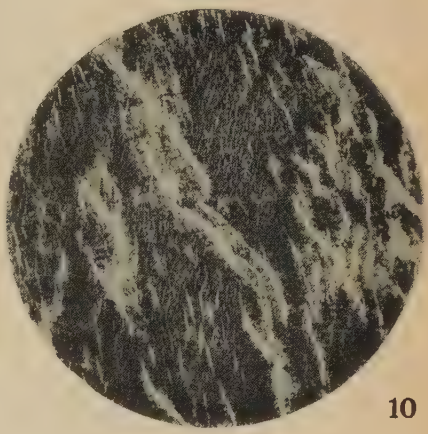

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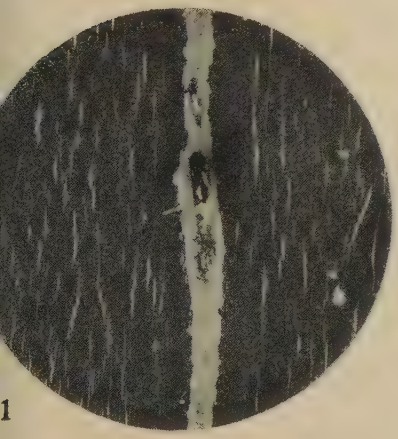

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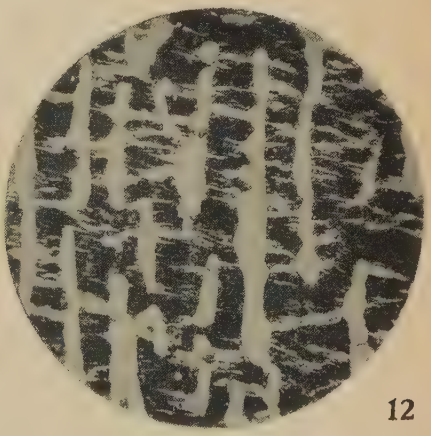

12

EDMONDSON SPENCER: MYRMEKITE IN GRAPHIC GRANITE AND VEIN PERTHITE.

MINERALOGICAL ABSTRACTS

(Vol. 9, No. 6, June, 1945.)

Physical Properties

MAN (*Sir* C. V.). *The crystal symmetry and structure of diamond.*[1] Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 189–198, 1 fig.

Four different crystal-structures of diamond are suggested in which the positions of the carbon atoms are similar, but in which the orientations of the tetrahedral carbon atoms in the two interpenetrating face-centred lattices differ. Two of these structures are tetrahedral and physically identical but geometrically different. Two are octahedral structures, not necessarily identical in physical properties. The four possibilities of orientating the carbon atoms correspond to the four different ways of securing extinction of the resultant magnetic moment. The author is of opinion that 'the X-ray findings leave the question whether diamond possesses tetrahedral or octahedral symmetry entirely open'. He then suggests that type I diamonds, the common variety showing infra-red absorption, consist of either of the two tetrahedral forms or of both in twin position. This would vindicate the views of earlier crystallographers that most diamonds are tetrahedral in symmetry. Only those of type II, the rarer variety of diamond, consist of either or both of the octahedral forms, and the lamellar structure parallel to (111) is due to inter-twinning on (111) as composition plane. Mixtures of the octahedral and tetrahedral forms within the same diamond crystal may also occur. F. A. B.

MAN (*Sir* C. V.). *The nature and origin of the luminescence of diamond.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 199–215, 4 pls.

A detailed study of the luminescence of 362 diamonds irradiated with ultraviolet light, 3500–4000 Å. These include 52 graduated Panna diamonds which are all rounded hexakis-octahedra (⅓–5 gm.); 65 cleavage plates, mostly of Indian origin; and 88 brilliants from South African diamonds. Luminescence is exhibited by nearly all the diamonds examined and with greatly varying intensities. Many of the cleavage plates exhibit luminescence patterns of geometrical character related to the crystal-structure. Very few diamonds are non-luminescent; they are type II, with a fine streaky birefringence due to lamellar twinning of the two octahedral forms of the crystal-structure of diamond. Type I diamonds, with tetrahedral symmetry, usually exhibit a blue luminescence and are isotropic. Diamonds in which the tetrahedral and octahedral forms of crystal-structure are intimately mixed show a greenish-yellow type of fluorescence, which is found under spectroscopic examination to be accompanied by the blue luminescence of diamond type I. Details of the X-ray fluorescence of diamond are also given. F. A. B.

[1] This and the following abstracts from 'Symposium of [17] papers on the structure and properties of diamond'. Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, no. 5, pp. 189–342.

Krishnan (R. S.). *The Raman spectrum of diamond.* Proc. Indian Acad. Sc. Sect. A, 1944, vol. 19, pp. 216–223, 1 pl.; Nature, London, 1945, vol. p. 171, 1 fig.

Two diamonds type II, were irradiated with a mercury arc giving the 2356 line. In addition to the strong Raman line of 1332 cm.$^{-1}$ frequency shift t others have been recorded, the existence of which is indicated by Raman's the of crystal dynamics. F. A. B.

Dayal (Bisheshwar). *The lattice spectrum and specific heat of diamond.* Pr Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 224–230.

The observed spectroscopic frequencies of diamond have been identified wi the particular modes of vibration of the crystal-structure given by Ram theory, and the specific heat of diamond then calculated for temperat 70–1100° K. The agreement with observed data is particularly good betwe 200 and 1100° K. where the thermal energy content is principally determine the optical frequencies of vibration. F. A. B.

Mani (Anna). *The fluorescence and absorption spectra of diamond in the visi region.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 231–252, 6 p 1 text-fig.

Thirty diamonds ranging in maximum linear dimension from 4 to 11 mm. a mostly colourless were studied at room and liquid-air temperatures. Over a wi range of intensity and colour of luminescence the spectra in all diamonds cons mainly of a doublet at 4152 Å., the width and separation of the compone increasing with intensity of blue luminescence, and a line at 5032 Å. showing such variation with intensity changes in the yellow fluorescence. A clear relati exists between the fluorescence and absorption spectra in the visible region. F. A. B.

Bai (K. Sunanda). *The ultra-violet absorption spectrum of diamond.* Proc. Indi Acad. Sci., Sect. A, 1944, vol. 19, pp. 253–260, 2 pls.

Nayar's observation that four absorption bands in the range 3030–3157 tend to disappear in strongly fluorescent specimens has been confirmed, and it now found that the ultra-violet transparency of diamonds increases with th intensity of fluorescence. Previous data, by Robertson, Fox, and Martin f non-fluorescent diamonds (type II) are confirmed. The absorption bands observ for diamonds showing both the blue and greenish-yellow types of fluorescence a given. These sharpen and shift towards the shorter wave-lengths at liquid- temperatures. F. A. B.

Hariharan (P. S.). *Intensity of X-ray reflection by diamond.* Proc. Indian Aca Sci., Sect. A, 1944, vol. 19, pp. 261–264.

The intensity of reflection by (111) of diamond is greater for non-fluoresci type II crystals. In blue fluorescing type I diamonds, which Raman supposes be intergrowths of the two tetrahedral forms, the intensity of X-ray reflecti increases with intensity of fluorescence. Diamonds exhibiting yellow fluorescen which Raman regards as intermixed tetrahedral and octahedral forms, refle

-rays from (111) with greater intensity than do the blue-fluorescing diamonds. is claimed that the observed phenomena are in agreement with Raman's theory the four structure-forms of diamond. F. A. B.

AMAN (*Sir* C. V.) & RENDALL (G. R.). *Birefringence patterns in diamond.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 265–273, 4 pls.

A series of natural crystals and polished cleavage plates have been examined tween crossed polaroids. Type I diamonds which possess blue luminescence e isotropic, showing that the two tetrahedral variants of the diamond structure hich interpenetrate in varying degrees possess identical crystal spacings. Bire- ingence in diamond may be of two kinds; irregular, when it is due to accidental perfections such as inclusions; and structural or geometrical, when regular tterns of birefringence appear. The non-luminescent type II diamonds invari- ly show this structural kind of birefringence, which is due to a difference in the ystal spacings of the two octahedral variants of the crystal-structure of diamond. irefringence patterns also arise from diamonds which are mixtures of the tetra- dral and octahedral variants. These results directly contradict the findings of obertson, Fox, and Martin [M.A. 6–6, 494], who found that type I opaque amonds were birefringent and the rarer type II transparent diamonds were otropic. Beautiful reproductions of photographs of the birefringent effects scribed are given. F. A. B.

AI (K. Sunanda). *Luminescence patterns in diamond.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 274–279, 4 pls.

Polished cleavage plates of diamond irradiated with long-wave ultra-violet ht frequently show regular luminescence patterns, which resemble closely the refringence pattern of the same plate examined between crossed polaroids in sible light. Lines in the pattern often run parallel to faces of the crystal from ich the plate was cleaved. The author also describes diamonds exhibiting a iform blue luminescence with no pattern and diamonds showing blue and llow luminescence in which patterns are always present. Local variations in e ultra-violet absorption spectrum reveal that a luminescence pattern is due to e intrusion of diamond having properties different from the rest of the crystal. F. A. B.

AMACHANDRAN (G. N.). *X-ray topographs of diamond.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 280–292, 2 pls., 2 text-figs.

An X-ray topograph is an enlarged Laue spot obtained by bathing the entire ystal, set at the correct angle for a given plane, in a beam of white X-radiation verging from a pin-hole. Reproductions of topographs of eighteen cleavage tes of diamond show that for the majority there is a variation of intensity of ray reflection over the area of a crystal plate. The relationship of these patterns those encountered in studies of luminescence, birefringence, and transparency ultra-violet is discussed. All these patterns can be interpreted in terms of the saic structure produced by the interpenetration of Raman's four variants of diamond crystal-structure. F. A. B.

Rendall (G. R.). *Ultra-violet transparency patterns in diamond.* Proc. Indi Acad. Sci., Sect. A, 1944, vol. 19, pp. 293–297, 2 pls.

Using the same diamonds whose luminescence patterns have been studied Sunanda Bai, their variation in transparency to short-wave ultra-violet radiati 2536 Å. has been investigated. The variations of transparency in any one pla of diamond are obtained by photographing the shadow cast on to a plate uranium glass. Many of the patterns obtained are reproduced showing similari to the luminescence patterns and in some instances a reversal. F. A. F.

Krishnan (R. S.). *Experimental evidence for the existence of the four possi structures of diamond.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 1 pp. 298–303, 1 pl.

The two tetrahedral variants should possess the same X-ray spacings. T heterogeneity of a diamond consisting of an intergrowth of the two should, ho ever, be revealed by the increased intensity of X-ray reflection. This has be confirmed for diamonds (type I) giving varying degrees of blue fluorescen The most brightly fluorescing give the most intense X-ray reflection. The tw octahedral variants should, however, possess slightly different spacings. A no fluorescent diamond (type II) with broadly spaced birefringent laminae yield variations in the X-ray spacings of 5 parts in 10,000 measured from the wa Bragg reflections obtained. The Raman frequency shift 1332 cm.$^{-1}$ is broad for type II than type I diamond in accordance with theory. F. A. B.

Ramachandran (G. N.). *X-ray reflection and the structure of diamond.* Pro Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 304–309, 1 fig.

Laue photographs along a trigonal axis of two (type I) blue-fluorescent, is tropic diamonds show that the strongly fluorescent gives the stronger La pattern. Microphotometry of the peak intensity of the spots shows that althou the intensity of all the spots is greater with the more fluorescent diamond, t ratio of the intensities of the corresponding spots varies. Moreover, this rat depends linearly upon the product of the structure factor, the wave-leng reflected, and a function of the angle of incidence. F. A. B.

Sigamony (A.). *Magnetic susceptibility of diamond.* Proc. Indian Acad. Sc Sect. A, 1944, vol. 19, pp. 310–314.

The magnetic susceptibility of 40 diamonds measured with a Curie balan ranged from $-0{\cdot}456$ to $-0{\cdot}411\times10^{-6}$. Two specimens of strongly fluoresce diamond showed no change in magnetic susceptibility when exposed to an inte beam of light. F. A. B.

Pant (Devi Datt). *The photoconductivity of diamond. Part I: Experimental resul* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 315–324, 1 fig.
—— *Part II: Theoretical considerations.* Ibid., pp. 325–333, 1 fig.

Thirty-six diamonds have been submitted to ultra-violet or visible light a their photoconductivity measured. Three types can be distinguished accordi to the magnitude of the effect, whereas Robertson, Fox, and Martin [M.A. 6- 494] proposed two types. Weakly photoconducting diamonds do not give t

l light effect. The variations in photoconductivity are explained on the basis Raman's four variants of the crystal-structure of diamond, assuming that otoconductivity resides in the heterogeneity due to the intermingling of the riants. F. A. B.

MASESHAN (S.). *The crystal forms of the Panna diamonds.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 334–342, 2 pls., 19 text-figs.

Describing and figuring the external forms and surface characters of 29 Panna monds. Not one exhibits plane faces or straight edges, being mostly distorted akis-octahedra or tetrakis-hexahedra with finely striated curved faces. The rvatures of the faces of four diamonds have been measured and found to be hly variable. F. A. B.

AGAVANTAM (S.) & BHIMASENACHAR (J.). *Elastic constants of diamond.* Nature, London, 1944, vol. 154, p. 546.

By measuring the frequency of ultrasonic waves transmitted through octa- dral and dodecahedral plates of diamond of known thickness the following ues of elastic constants have been obtained: C_{11} 9·4, C_{12} 4·2, C_{44} $4{\cdot}2\times10^{12}$ nes per sq. cm. F. A. B.

ISHNAN (R. S.). *Thermal expansion of diamond.* Nature, London, 1944, vol. 154, pp. 486–487.

The thermal expansion of diamond has been measured by an X-ray method er the range 25–650° C.; at 25° it is $4{\cdot}50\times10^{-6}$, and at 650° $12{\cdot}30\times10^{-6}$. From data it is calculated that the Grüneisen relationship connecting the specific at and thermal expansion is not constant. F. A. B.

AGAVANTAM (S.). *Normal oscillations of the T_d class diamond structure.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 20, pp. 122–127, 1 fig.

An application of group theory to the normal oscillations of the diamond ucture. F. A. B.

NI (Anna). *Polarisation of Raman scattering and of fluorescence in diamond.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 20, pp. 117–121.

Depolarization factors for the principal Raman line of an isotropic octahedron diamond were measured and found to differ from the theoretical values pre- ted by Saksena (1940). With incident unpolarized light the fluorescence bands the 4152 system appear depolarized, but polarized when incident polarized at is used. F. A. B.

NI (Anna). *Spectroscopic study of luminescence patterns in diamond.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 20, pp. 155–161, 1 pl.

A description of the local variations in intensity and colour of the fluorescent iation from six cleavage plates of diamond showing blue, yellow, and mixed es of luminescence. F. A. B.

YAL (Bisheshwar). *The specific heat of metals crystallising in the cubic system.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 20, pp. 24–49, 4 figs.

The specific heats of the cubic face-centred metals Al, Ag, Au, Cu, and Pb and

of the body-centred metals Li, K, Na, and W were calculated from Rama theory and found to be in fair agreement with the experimental data.

F. A. H

SAKSENA (Bishambhar Dayal). *The thermal expansion of diamond.* Proc. Ind Acad. Sci., Sect. A, 1944, vol. 20, pp. 92–99.

Grüneisen's law of thermal expansion which fits the data for lower temperat assumes a single constant γ for diamond not in accordance with Nayar's obser tions of the change of the Raman frequency shift in diamond with temperat By assuming two values γ, one for the lower and one for the higher frequen values of the coefficient of expansion at high temperatures are calculated w are larger than those predicted by Grüneisen. F. A. B

DAYAL (Bisheshwar). *The theory of the thermal expansion of diamond.* Pr Indian Acad. Sci., Sect. A, vol. 20, pp. 187–191.

The values of the Grüneisen constants γ for the eight vibration frequencies diamond have been derived and the thermal expansion then calculated show be in good agreement with experimental data at both low and high temperatur The heat of vaporization of diamond has also been calculated. F. A. B

SAKSENA (Bishambhar Dayal). *Calculation of the elastic constants of quartz room temperature from the Raman effect data.* Proc. Indian Acad. Sci., Sect. 1944, vol. 19, pp. 357–369, 1 fig.

There are four force constants involved in the silicon-oxygen bonds of t α-quartz structure which have been calculated from the Raman and infra-r data. Thence the elastic constants are calculated and are found to be in agre ment with the observed values. F. A. B.

RAO (B. Sundara Rama). *Raman effect in relation to crystal structure: sodiu nitrate.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 93–99.

By adopting a set of four force constants, four related to the free ion and thr to interionic forces in the crystal, the observed Raman and infra-red spectra single crystals of $NaNO_3$ have been explained. F. A. B.

BHAGAVANTAM (S.) & VENKATESWARLU (K.). *Scattering of light in single crysta* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 108–110.

The Rayleigh and Raman scattering in 1-inch flawless cubes of calcite a quartz have been determined for different orientations. The Rayleigh line has intensity of two to seven times that of the principal Raman line. F. A. B.

DAYAL (Bisheshwar). *The evaluation of the specific heat of rock-salt by the ne crystal dynamics.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 182–18

Raman's theory of crystal dynamics postulates that the rock-salt structure ha nine frequencies of vibration in the optical branch, which represent forty-five o of the forty-eight degrees of freedom of the group of eight sodium and eig chlorine ions in a super-lattice cell. The remaining three degrees of freedom repr

t the spectrum of the elastic vibrations of the lattice. The thermal energy culated on these assumptions is in agreement with the experimental data.
F. A. B.

YAL (Bisheshwar). *The specific heats of the alkali halides.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 20, pp. 77–86.

greement is obtained between experimental values and those calculated ording to Raman's theory of crystal vibrations. F. A. B.

YAL (Bisheshwar). *The specific heat of metallic silicon.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 20, pp. 87–91.

he specific heat of silicon at 40° K. is four times the value calculated from oye's theory. Excellent agreement, however, is obtained with theoretical ues based on Raman's theory over the range 20–1000° K. F. A. B.

YAL (Bisheshwar). *Lattice spectrum, specific heat, and thermal expansion of lithium and sodium fluorides.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 20, pp. 138–144.

alues calculated on the basis of the Raman dynamics of crystal vibrations. agreement between theory and experiment for lithium fluoride is satisfactory.
F. A. B.

YAL (Bisheshwar). *Theory of the thermal expansion of the alkali halides.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 20, pp. 145–154.

alues of the Grüneisen constant γ have been calculated for all the frequencies n by Raman's theory, in the case of NaCl, KCl, and KBr. Using these values coefficients of expansion then derived agree well with experimental data. The o of thermal expansion to specific heat decreases gradually as the temperature s, thus explaining the decrease observed by Lindemann (1912) for rock-salt.
F. A. B.

YAL (Bisheshwar). *The thermal expansion of metals at low temperatures.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 20, pp. 192–199.

he Grüneisen theory is in reasonable agreement with the determinations of mal expansion for Al, Ag, Cu, Au, and Pb, but fails, just as Debye's formula specific heats does, in the case of the body-centred metals W, Li, and Na.
F. A. B.

AMONY (A.). *The magnetic susceptibility and anisotropy of carborundum.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 19, pp. 377–380.

green hexagonal plate of carborundum showed no anisotropy in the plane pendicular tc the hexagonal axis, a mean gm. mol. susceptibility of $-12{\cdot}8\times$, and anisotropy $\chi_{\parallel}-\chi_{\perp}$ (parallel and perpendicular to the hexagonal axis) 82×10^{-6}. Black carborundum is diamagnetic, but irregular in its behaviour.
F. A. B.

AMONY (A.). *The magnetic properties of tourmaline and epidote.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 20, pp. 200–203.

leven tourmalines and two epidotes of known specific gravity (localities not

given) vary in paramagnetic susceptibility from $0{\cdot}58 \times 10^{-6}$ for rose-coloured (sp. gr. 3·03) to $13{\cdot}4 \times 10^{-6}$ for dark-brown or black specimens (sp. gr. 3·15); darker tourmalines are also the more anisotropic. The values obtained for epi (sp. gr. 3·45 and 3·46) were 22·7 and $23{\cdot}6 \times 10^{-6}$ and their anisotropy is very sm F. A. I

Sigamony (A.). *Magnetic behaviour of iron-pyrites.* Proc. Indian Acad. Sect. A, 1944, vol. 20, pp. 204–209.

Forty-five crystals of pyrite from Nepal (specific gravity of each of six were investigated with the Curie balance, yielding magnetic susceptibilities fr 0·2 to 190×10^{-6}; only a few possess high values, and these are anisotropic. susceptibility is nearly independent of temperature change. F. A. B

Raman (*Sir* C. V.). *The vibration spectrum of a crystal lattice.*[1] Proc. Indian Ac Sci., Sect. A, 1944, vol. 18, pp. 237–250.

The atomic vibrations repeat themselves in a space-pattern of which the has twice the dimensions in each direction and therefore eight times the vo of a unit cell of the crystal lattice. Each of the atoms contained in this unit 24 degrees of freedom yielding $24p-3$ normal modes of vibration for a unit containing p atoms. The spectrum thus consists of a finite number of mo chromatic frequencies, which is further reduced when the crystal possesses h symmetry. The residual 3 degrees of freedom are assigned to lower quasi-elas vibrations of lower frequency. Nayar's spectroscopic data are stated to supp this theory and contradict Born's. F. A. B

Bhagavantam (S.). *Normal oscillations of the diamond structure.* Proc. Ind Acad. Sci., Sect. A, 1944, vol. 18, pp. 251–256, 1 fig.

The theory of groups is applied to obtain the normal oscillations of the diamo structure based upon a 16-atom cell. The oscillations are classified and expressic derived for the corresponding normal frequencies. F. A. B.

Chelam (E. V.). *The normal vibrations in some typical cubic crystals.* Proc. Indi Acad. Sci., Sect. A, 1944, vol. 18, pp. 257–265.

Assuming Raman's theory of lattice vibrations the simple cubic, body-centre and face-centred lattices have 5, 4, and 4 normal modes of vibrations respectivel whilst the lattices of blende, diamond, rock-salt, fluorite, and calcium chlori have 9, 8, 9, 14, and 11 such frequencies. F. A. B.

Ramachandran (G. N.). *Modes of atomic vibration in the fourteen Bravais latti* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 18, pp. 266–282, 6 figs.

The number of distinct modes of vibration computed for the various latti are $\Gamma_{tr}21$; $\Gamma_m 21$, $\Gamma'_m 15$; $\Gamma_o 21$, $\Gamma'_o 15$, Γ''_o and $\Gamma'''_o 12$; $\Gamma'_t 12$, $\Gamma'_t 8$; $\Gamma_{rh} 8$, $\Gamma_h 8$; Γ_c $\Gamma'_c 4$, $\Gamma''_c 4$. F. A. B.

Chelam (E. V.). *Normal vibrations of crystal lattices: application of group theor* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 18, pp. 283–297.

Showing how the normal modes, frequencies, their degeneracies, &c. can rigorously derived for Raman's theory of lattice vibrations. F. A. B.

[1] This and the following abstracts from 'Symposium of [10] papers on the dynamics crystal lattices'. Proc. Indian Acad. Sci., Sect. A, 1944, vol. 18, no. 5, pp. 237–344.

ISHNAN (R. S.). *Raman spectra of crystals and their interpretation.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 18, pp. 298–308.

Rasetti's spectrograms of the Raman effect in rock-salt reveals nine distinct man lines. The frequency shifts of these lines have been estimated and the e lines identified with the nine modes of vibration to be expected from Raman's ory of lattice vibrations. It is claimed that Born's theory of crystal dynamics s not explain the observed phenomena. F. A. B.

NT (D. D.). *Luminescence spectra and vibrations in crystal lattices.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 18, pp. 309–326.

A general survey of the known luminescence spectra of crystalline substances given together with a list of references to the literature. Those which give crete spectra are divided into seven classes: (1) Diamond where the luminescence is probably due to some sort of mosaic structure. (2) The chromium nsition element) activated solids, e.g. ruby. (3) Solids containing rare-earth ments. (4) Solids containing foreign atoms scattered through their lattices. Some pure salts, e.g. the uranyl compounds. (6) Organic compounds possessing a double bond, e.g. solid benzene. (7) Solidified gases, e.g. solid nitrogen. is emphasized that in all crystalline compounds from covalent diamond to typical van der Waals' compound solid nitrogen the observed spectra are rp and monochromatic. F. A. B.

ELAM (E. V.). *Character tables for the atomic vibrations in some cubic crystals.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 18, pp. 327–333.

Character tables for groups associated with vectors defining normal modes are en for four substances with crystal-structures based on a face-centred lattice: k-salt, diamond, blende, and fluorite. F. A. B.

ELAM (E. V.). *The frequency spectrum of the diamond lattice.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 18, pp. 334–340.

Based upon Raman's theory of lattice vibrations, the eight frequencies in a mond lattice are calculated. F. A. B.

MACHANDRAN (G. N.). *Modes of vibration of the hexagonal close-packed lattice.* Proc. Indian Acad. Sci., Sect. A, 1944, vol. 18, pp. 341–344.

Character tables are given and the degeneracies given for the 13 vibrations ved at from Raman's theory. F. A. B.

ND (Walter L.). *The mathematics of the physical properties of crystals.* Bell System Technical Journ. New York, 1943, vol. 22, pp. 1–72, 39 figs.

n elementary treatment of matrix algebra is followed by applications to the ory of elasticity of crytals, the piezo-, pyro-, and thermo-electric effects; the pagation of light through crystals; the electro- and the piezo-optical effects. eograms showing the symmetry elements of the 32 crystal classes are neatly red. F. A. B.

LLEUX (André). *Mesure des densités par comparaison avec des sables.* Compt. Rend. Acad. Sci. Paris, 1943, vol. 217, pp. 30–31.

linerals of sp. gr. less than that of quartz when gently shaken horizontally in

fine sand (0·3 mm. grain-size) remain on the surface, whilst those of greater sp. g
are submerged. L. J. S.

Williams (Samuel R.). *Hardness and hardness measurements.* Cleveland, O.
(Amer. Soc. Metals), 1942, viii+558 pp., 2 pls., 338 text-figs. Price $7.

An exhaustive treatise by the professor of physics in Amherst College, Mas
chusetts, dealing with the theories and definitions of hardness, relation to ato
structure, and the various methods and instruments for its determination.
detailed bibliography occupies 84 pages, and the frontispiece gives a portrait
F. Mohs (1772–1839). L. J. S.

Spaeth (W.). [*Physik und Technik der Haerte und Weiche.* Berlin, 1940, 250 p
214 figs.] *Hardness and softness.* Review in Industrial Diamond Revie
London, 1945, vol. 5, pp. 3–8, 13 figs.

Hardness is defined as resistance to indentation and is measured by loa
volume removed (h = kg./c.mm.). Formulae are given connecting this value wi
those of the Brinell, Rockwell, Knoop (1939, not mentioned by Spaeth) rebou
and scratch methods. Softness is $w = 1/h$. L. J. S.

Rayleigh (*Lord*). *Pebbles, natural and artificial. Their shape under varic
conditions of abrasion.* Proc. Roy. Soc. London, Ser. A, 1944, vol. 1
pp. 321–334, 3 pls., 9 text-figs.

——*Pebbles of regular shape, and their reproduction in experiment.* (Discours
Roy. Inst.) Nature, London, 1944, vol. 154, pp. 169–171, 2 figs.

Further experiments with marble abraded by 'pothole' action. [M.A. 8–347
L. J. S.

Baturin (V. P.) Батурин (В. П.). *A new method for studying sandy silt sedimen
(granulo-morphological analysis).* Compt. Rend. (Doklady) Acad. Sci. URS
1942, vol. 37, pp. 66–68.

Conditions for the separation of minerals by sliding on an inclined surface a
discussed. Size and shape of the grains have an important influence, but wh
these are the same different minerals have different friction coefficients on differe
surfaces. L. J. S.

Birch (Francis). *Elasticity of igneous rocks at high temperatures and pressur
Bull. Geol. Soc. Amer., 1943, vol. 54, pp. 263–285, 4 figs.

The rigidity and velocity V_s of shear waves were determined for a number
igneous rocks at temperatures up to 600° C., and at pressures of from 3000
9000 kg./cm.^{2} Rocks investigated include quartzite, albitite, anorthosit
bronzitite, amphibolite, dunite, marble, granites, quartz-diorite, diabase, gabb
and eclogite. A new analysis of pyroxene from eclogite, from near Occidenta
Sonoma Co., California, (anal. F. A. Gonyer) gives SiO_2 53·31, TiO_2 0·26, Al_2O
10·52, Fe_2O_3 4·11, FeO 2·84, MnO 0·05, MgO 8·42, CaO 14·50, Na_2O 5·90, K_2
0·05, H_2O+ 0·16 [= 100·12]. C. F. D.

Rosenholtz (Joseph L.) & Smith (Dudley T.). *Thermal studies of orthoclase a
microcline.* Amer. Min., 1942, vol. 27, pp. 344–349, 3 figs.

Rods (10×4×4 mm.) cut parallel to the crystallographic axes of a crystal

crocline from Bedford, New York, were examined as previously described .A. 8–69, 205]. This material has sp. gr. 2·544, α 1·518, β 1·522, γ 1·525, and ntains SiO_2 65·10, TiO_2 0·01, Al_2O_3 18·80, $Fe_2O_3 + FeO$ 0·10, MgO 0·09, CaO 0·02, $_2O$ 1·99, K_2O 14·14, H_2O+ 0·11, H_2O- 0·01 = 100·37, corresponding to $Or_{83·5}$ $_{16·5}$. The mean coefficient of linear expansion along the *a*-axis is $14·96 \times 10^{-6}$ m 0° to 100° C., increasing to $17·85 \times 10^{-6}$ to 1000°; along the *b*-axis $0·49 \times 10^{-6}$ 100°, decreasing to −0·04 to 500°, and increasing to 1·18 to 1000°; along the xis $0·49 \times 10^{-6}$ to 100°, increasing to 1·30 to 1000°. Abrupt volume changes ur at 20 points between 100° and 985° C. Orthoclase ($Or_{71·8}Ab_{23·8}An_{2·4}$) m Good Springs, Nevada, shows 11 abrupt volume changes between 190° and)° C. Curves of linear expansion of adularia show a decrease from 900° to 1000°, l there are 12 abrupt volume changes. There is thus an essential distinction ween the thermal behaviour of microcline and orthoclase. [M.A. 8–148.]

L. J. S.

APP (W. J.). *Thermal conductivity of nonmetallic single crystals.* Journ. Amer. Ceramic Soc., 1943, vol. 26, pp. 48–55, 11 figs.

Determinations over a range of about 100–500° C. were made in a specially nstructed apparatus on 1 cm. cubes with faces cut perpendicular and parallel the *c*-axis of clear crystals of quartz, corundum, artificial sapphire, beryl, aaz, zircon, periclase, lithium fluoride, mullite (bundles of parallel crystals), l glasses including silica-glass. With increasing temperature there is in general slight increase in conductivity, but along the *c*-axis of quartz a decrease. .A. 8–68.]

L. J. S.

ND (W. L.). *A mineral survey of piezo-electric materials.* Bell System Techn. Journ., New York, 1943, vol. 22, pp. 145–152.

An alphabetical list of 830 minerals gives the crystal-class (when known) with ications of the availability of the material. Many others besides those (70) in ich a centre of symmetry is lacking were examined for piezo-electric effects by method of Giebe and Scheibe (Zeits. Physik, 1925, vol. 33, p. 761), mostly h negative results. The following were found to be active: quartz, tourmaline, nde, hemimorphite, epsomite, boracite, stibiotantalite, scolecite, struvite, yite, langbeinite, leucophane, meliphane, wurtzite, tiemannite, epistilbite, hohedrite, cronstedtite, and edingtonite. No reaction was obtained with mond and iodyrite.

L. J. S.

SON (W. P.). *Crystals of quartz.* Bell Laboratories Record, New York, 1944, vol. 22, pp. 282–289, 7 figs.

A simplified explanation of the use of quartz plates as oscillators and a descrip- n with figures of the various cuts in use, with charts showing their frequency stants and temperature coefficients, and the relationship between the frequency the AT, BT, and GT cuts and temperature. The use of the word 'crystal' for plates cut from crystals of quartz is somewhat confusing.

W. C. S.

JL (B. M.). *Dielectric permeability of rutile mixtures.* Compt. Rend. (Doklady) Acad. Sci. URSS, 1944, vol. 43, pp. 292–294, 2 figs.

Rutile has a high dielectric permeability ϵ 114, and it has been used in high-

frequency ceramic capacitors. For TiO_2 with MgO ϵ decreases to 13 at the co pound $MgTiO_3$, but with dolomite only to ϵ 70; the former has a posi temperature coefficient and the latter a negative. L. J. S.

Crystal-optics

[Боку (G. B.)] Бокий (Г. Б.). Кристаллооптический анализ. [*Crystallo-optic analysis.*] Инст. Общ. и Неорган. Химии, Акад. Наук СССР [I General and Inorg. Chem., Acad. Sci. USSR], 1944, 156 pp. Price 11*r*.

A tabulation of 820 inorganic and organic substances in order of refrac indices (1·266–4·04), giving also the crystal system, habit, cleavage, col specific gravity, &c. L. J. S.

Preston (G. D.). *Microscopy with light, electrons and X-rays.* Journ. Sci. In 1944, vol. 21, pp. 205–213, 12 figs.

A simple wave-theory treatment of the derivation of the formula for t resolving power of a microscope is followed by an account of the analogy betwe optical lenses for light and electrostatic and magnetic lenses for electrons. T author also points out how the formation of a diffraction pattern of a crystal X-rays resembles the formation of an optical image by a microscope. F. A. B.

Hallimond (A. F.). *Use of 'polaroid' for the microscope.* Nature, London, 194 vol. 154, pp. 369–371, 2 figs.

Improved polaroid disks of a neutral smoky tint when crossed transmit on 0·0015 % light compared with 0·0052% for crossed nicol prisms. Using a Bere type of photometer, comparative extinction curves have been obtained plottin intensity of light with angle of rotation of one polaroid disk or nicol prism. light absorption curve of one polaroid disk for the visible spectrum is also repr duced. There is a slight increase in absorption in the blue-green, but otherwise n evidence of absorption bands. The transmitted beam which would be reduced t 50% by a nicol prism would be reduced to 33% by one polaroid disk owing to it greater absorption. If polaroid were employed in a microscope, this differenc would be more than compensated by the greater working diameter of the co denser. The new polaroid has properties which render it suitable for use i polarizing microscopes not only for students but for research workers as well. F. A. B.

Tertsch (H.). *Zur graphischen Berechnung der Brechungsquotienten für ein beliebige Richtung eines doppelbrechenden Kristalles aus der optischen Indika trix.* Zeits. Krist., 1942, vol. 104, pp. 446–450, 2 figs.

A graphical construction for obtaining the refractive indices in any section o the Fletcher indicatrix. L. J. S.

Faick (Conrad A.) & Fonoroff (Bernard). *A precision apparatus for the rapi determination of indices of refraction and dispersion by immersion.* Journ Research National Bureau of Standards, Washington, 1944, vol. 32, pp. 67 75, 1 pl., 2 text-figs.

A development of Saylor's method [M.A. **6**–458] of oblique illumination usin

uble diaphragms for rough samples of optical glass. The refractive index can be asured at a given temperature with an average error of $\pm 1{\cdot}9 \times 10^{-5}$ and a ximum error of $\pm 5 \times 10^{-5}$. The apparatus used is fully described and may used not only for controlling the composition of batches but also for the ermination of the optical constants of finished optical components, especially flint glass. F. A. B.

RGUSON (R. B.) & PEACOCK (M. A.). *Measurement of the three principal indices of refraction in micaceous minerals by immersion on a tilting stage.* Amer. Min., 1943, vol. 28, pp. 563–570, 4 figs.

With α normal or nearly normal to the cleavage, the flake is tilted about the β or xis until the refractive index coincides with that of the immersion liquid; α can n be calculated from the angle of tilt and β or γ. Muscovite from Mattawan, tario [M.A. **9**–57] gave by this method α 1·567 (compared with $1{\cdot}566_5$ obtained the total refractometer); β 1·606, γ 1·611 determined on the horizontal stage. L. J. S.

ITZER (George). *Butyl "carbitol" as an immersion liquid.* Amer. Min., 1944, vol. 29, pp. 389–391, 2 figs.

Butyl 'carbitol' is a colourless, almost odourless, slightly viscous liquid, boiling nt 231·2° C. with low temperature coefficient and low dispersion. It is mis-le in all proportions with monochlornaphthalene giving a continuous series of uids with n 1·43–1·63, also with monobromnaphthalene 1·43–1·66, and with ter 1·34–1·43. The straight line graphs of dispersion and temperature coeffi-nt with refractive index of butyl 'carbitol' are reproduced. F. A. B.

POV (I. V.). *The cryptostructure of clays during their deformation.* Compt. Rend. (Doklady) Acad. Sci. URSS, 1944, vol. 45, pp. 162–164, 2 figs.

The feeble anisotropism induced in a paste (200% water) of montmorillonitic -clay pressed beneath a cover-glass is conveniently shown with a gypsum plate sitive violet tint of the first order) between crossed nicols, when blue and low spots are seen. Inserting a wire or strip of mica beneath the cover-glass mented along three edges) regions of pressure and tension are shown by blue) and yellow (n'_g) colours respectively. It is concluded that the basal planes he clay crystals become oriented perpendicular to the direction of pressure l their lengths in the direction of stretching, producing in the mass an 'anchi-stalline cryptostructure'. L. J. S.

VES (F.) & ERNST (Th.). *Die Sichtbarmachung des Charakters (+ bez. −) äußerst schwacher Doppelbrechungseffekte.* Naturwiss., 1943, vol. 31, pp. 68–69.

More intense colour changes are shown when the gypsum plate is inserted at a ll angle (3°) to the polarizer, than in the usual diagonal position. L. J. S.

RTIE (John B. *Jr.*). *Nomograms of optic angle formulae.* Amer. Min., 1942, vol. 27, pp. 538–551, 1 pl., 2 text-figs.

harts based on modified equations are given for α, β, γ, V and α, β, γ, E to ermine any fourth when three are known; and for the equations $E = \beta \sin V$ $D = K \sin E$ (Mallard's formula). [M.A. **7**–249.] L. J. S.

Melmore (Sidney). *Conical refraction.* Nature, London, 1943, vol. 151, pp. 6[illegible] 621, 1 fig.

Further observations on the behaviour of focal lines in a biaxial crystal [M[illegible] 8–351]. Near the optic axes and the optic axial plane there is a divergence fr[illegible] Fresnel's wave-surface. L. J. S[illegible]

Jaffray (Jean). *Sur la biréfringence du gypse et de la barytine dans le r[illegible] extrême et le très proche infrarouge.* Compt. Rend. Acad. Sci. Paris, 19[illegible] vol. 216, pp. 409–410.

The extreme values determined for several wave-lengths are: gypsum, $\gamma -$ λ 6000 0·00917, λ 8600 0·00870; baryte, $\beta-\alpha$, λ 6000 0·001155, λ 8800 0·001[illegible] L. J. S[illegible]

Jaffray (Jean). *Sur les variations avec la température de la biréfringence du g[illegible] et de la barytine.* Compt. Rend. Acad. Sci. Paris, 1943, vol. 216, pp. 814–81[illegible]

Birefringence b on the cleavage of gypsum at 17° for wave-length λ 850[illegible] 0·00873, db/dt −0·00000555, and for λ 3500 0·00970, db/dt −0·00000615. F[illegible] baryte $\beta-\alpha$ on a plate $\perp$ Bx_a at 16° for λ 9000 is 0·001046, db/dt +0·000008 and for λ 3800 0·001442, db/dt +0·00000110. L. J. S[illegible]

Mäder (Josef). *Kristallographie und Optik des Kupfervitriols.* Schweiz. Min. Pe[illegible] Mitt., 1942, vol. 22, pp. 197–232, 6 figs., 3 folding tables.

Goniometric measurement of artificial crystals of copper sulphate showi[illegible] 12 crystal-forms gave $a:b:c$ = 0·56890:1:0·55494, α 82° 22′ 31″, β 107° 16′ 27 γ 102° 35′ 11″. An elaborate exercise is given for obtaining the optical constan[illegible] of a triclinic crystal by the prism method following L. Weber [M.A. 1–36[illegible] Results are given for yellow, green, and violet light: for yellow (5876) α 1·5141 β 1·53691, γ 1·54362; for violet (4471) α 1·52425, β 1·54778, γ 1·55496. The optic orientation was deduced from the extinction-angles on different faces. L. J. S.

Tolansky (S.). *An interferometric procedure for the examination of crystal surface* Nature, London, 1943, vol. 152, pp. 722–723, 2 figs.

—— *Topography of a quartz crystal.* Ibid., 1944, vol. 153, pp. 195–196, 2 figs.

The silvered surfaces are placed against an optical flat and the interferen[illegible] fringes observed. On cleavage surfaces of mica and gypsum these are very distin[illegible] in character. Outlines of vicinal faces are shown on a (100) face of quartz. L. J. S.

Nikitine (Serge). *Contribution à l'étude du photodichroïsme de lames colorées [illegible] NaCl.* Compt. Rend. Acad. Sci. Paris, 1943, vol. 216, pp. 758–760, 1 fig.

Thin sections of artificial crystals of NaCl coloured by X-rays show photo dichroism when exposed to polarized white light. A section that has been partl decolorized and made anisotropic by the action of polarized light must be com pletely decolorized and recoloured by X-rays before it will again show photo dichroism. The action of polarized monochromatic light was also studied [M.A. 8–264.] L. J. S.

Pseudomorphs

OPSY (U.). *Sur un moulage en trémie de halite de Beaume de Venise (Vaucluse).* Bull. Soc. Franc. Min., 1938, vol. 61, pp. 205–208, 1 fig.

Description of a pseudomorph of dolomite after a hopper-shaped crystal of k-salt, 4×4×2 cm. F. A. B.

TH (E.). *Remarkable moulds of hopper-shaped halite crystals from Manitoba.* Univ. Toronto Studies, Geol. Ser., 1941, no. 46, pp. 69–73, 7 figs.

Limestone boulders, apparently from the Silurian Stonewell Series, between ke Winnipeg and Lake Manitoba, show beautifully preserved and clearly otographed casts of salt hoppers measuring 2·3 to 2·8 inches along the cube-e. M. A. P.

TLEY (Edgar H.). *Skeletonized apophyllite from Crestmore and Riverside, California.* Amer. Min., 1941, vol. 26, pp. 565–567.

Apophyllite crystals changed to hydrated silica (SiO_2 88·54, H_2O 7·21%, with ne MgO, &c.) retain their form and pearly basal cleavage, with uniaxial optic ture and ω 1·449, ϵ 1·439. This change is similar to the baueritization of tite and the leaching of zeolites by acid, leaving a silica skeleton with the cture not entirely destroyed. L. J. S.

DREWS (D. A.) & SCHALLER (W. T.). *Dolomite pseudomorphous after crystals of aragonite.* Amer. Min., 1942, vol. 27, pp. 135–140, 3 figs.

Twinned pseudo-hexagonal crystals (1–2 inches across and ¼ inch thick) of gonite replaced by a granular aggregate of dolomite occur in a gypsum bed in mian red beds near Kane on the Big Horn river in Wyoming. Analysis gave $_2$ 45·65, SO_3 0·98, P_2O_5 trace, R_2O_3 (mainly limonite) 0·18, MgO 21·12, CaO 60, H_2O+ 0·89, H_2O- 0·33, insol. 0·28 = 100·03. Similar pseudomorphs have been found at Dunlap, De Baca Co., New Mexico. L. J. S.

HAEFER (Vincent J.). *Use of snowflake replicas for studying winter storms.* Nature, London, 1942, vol. 149, p. 81, 1 fig.

— *How to fingerprint a snowstorm.* Nat. Hist. (Amer. Mus. Nat. Hist.), 1943, vol. 51, pp. 20–27, 33 figs.

Crystals of snow, ice, benzene, acetic acid, &c., may be preserved in resin licas by covering the crystal with a cold 1–2% solution of polyvinyl formal in ylene dichloride. After evaporation of the solvent the crystal sublimes or lts and leaves a solid replica. The second title is of a popular and well-illustrated icle. F. A. B.

UNTAIN (Edgar D.). *Bubbles in polyhedral geodes from Swaziland.* Trans. Roy. Soc. South Africa, 1942, vol. 29, pp. 1–7, 4 figs.

Polyhedral quartz 'geodes' from tin mines in Mbabane, Swaziland, probably ived from pegmatite or granite and measuring up to 4 inches diameter, fre-ntly possess cavities containing liquid with gas bubbles. Analysis shows t the liquid is water, *p*H 6·6, with some dissolved carbon dioxide; and that the is of volume composition nitrogen 75, oxygen 22, carbon dioxide 3. The gas s confined under a pressure of 14 atmospheres. The 'geodes' are believed to

have been formed from silica gel deposited in cavities bordered by crystal face an unknown mineral. C. F. D.

Åhman (Erik). *Eine Pseudomorphose des Skapoliths von Malmberget.* Bull. Geol. Inst. Univ. Upsala, 1943, vol. 30, pp. 155–163, 5 figs.

An isolated prismatic pseudo-crystal with the form of scapolite shows a cr of small (0·5–1 mm.) water-clear crystals of albite (Ab 95–98) in parallel pos and with the *c*-axes approximately parallel to the *c*-axis of scapolite. This is lowed by a zone of irregularly oriented albite (Ab 85–88) crystals, and the c consists of cleavelandite with chlorite, iron hydroxide, and magnetite. L. J. S.

[Shcherbina (V. N.)] Щербина (В. Н.). Псевдоморфозы серпентина по а нолиту. Доклады Акад. Наук СССР, 1943, vol. 41, pp. 185–187.

Stcherbina (V. N.). *Serpentine pseudomorphs after actinolite.* Compt. R (Doklady) Acad. Sci. URSS, 1943, vol. 41, pp. 176–177, 2 figs.

The serpentinite massif of Ebeita near Orsk consists of antigorite. In t parallel crush zones the rock consists of microantigorite [Min. Mag. **23**–634] w strings of cross-fibre chrysotile; and in the central part of the zones of actinoli asbestos, mainly of the slip-fibre type, but some of the cross-fibre type repla chrysotile. One lens, around a nodule of chromite, consists of radial cry 8–10 cm. long with the optical characters and chemical composition of serpenti but containing some residual actinolite. This indicates two periods of serpenti zation. L. J. S.

Strunz (H.). *Beitrag zum Pyrolusitproblem.* Naturwiss.. 1943, vol. 31, pp. 89–9 3 figs.

According to X-ray data [Min. Mag. **24**–521] pyrolusite is identical with tetr gonal polianite, while examination under the ore microscope gives it as orth rhombic. This supports the view that it is a pseudomorph of polianite after son other manganese mineral, usually manganite. L. J. S.

Miscellaneous

Baker (George). *Sand stalagmites.* Journ. Geol. Chicago, 1942, vol. 50, pp. 66 667, 4 figs.

Sand stalagmites of curious shapes are found buried in the loose sand on t floor of a limestone cave in Loch Ard gorge near Port Campbell, Victoria, Australi They are formed by the cementing together of the sand grains by drips fro stalactites. L. J. S.

Fischer (Werner). *Die präparative Gewinnung von seltenen Erd- und Beryllium Verbindungen aus Gadolinit.* Zeits. Anorg. Chem., 1942, vol. 250, pp. 72–8

Gadolinite is decomposed by conc. HCl, rare-earths precipitated as oxalat and Be distilled as basic acetate. L. J. S.

Goldring (E. D.). *An occurrence of ilsemannite.* Amer. Min., 1942, vol. 2 pp. 717–719.

Ilsemannite, $MoO_3.SO_3.5H_2O$, occurs as an azure to blackish-blue powde incrustation on fluorite or altered granite in northern Jackson Co., Colorado. F. A. B.

RES (Vincent L.). *Struvite in canned lobster.* Amer. Min., 1942, vol. 27, pp. 387–388.

The crystals show an unusual habit in being elongated along the *a*-axis with brachydomes *q* and *h*, other forms being *p b c*; *s* is present as a single face na's letters]. [M.A. 2–184, 3–60.] L. J. S.

EOBRAZHENSKY (I. A.) [Преображенский (И. А.)]. *Native iron in the Komi ASSR.* Compt. Rend. (Doklady) Acad. Sci. URSS, 1944, vol. 43, pp. 26–29, 3 figs.

urassic clays and overlying morainic deposits with chalybite concretions on Sysol river, south of Syktyvkar, Komi autonomous republic, contain minute to 0·25 mm.) irregular grains and flakes of metallic iron, which are soluble in l, reduce copper from copper sulphate solution, and sometimes give a faint ction for nickel. They are attached to grains of brown-iron-ore, magnetite, i pyrite, or scales of chlorite, and are often associated with vegetable fibres, he reducing action of which they evidently owe their origin. Other localities he same region in northern Russia for similar occurrences of native iron are: Timan district [M.A. 8–142]; Kozhim river, a tributary of the Kos-yu, in boniferous shales; Pizhma river, a tributary of the Pechora, in Devonian dstones and conglomerates, where thin (0·02 mm.) lamellae (0·97 × 0·66 mm.) ron occur as a coating on flakes of delessite. L. J. S.

LLÈRE (*M*^{lle} Simonne). *Sur un nouveau type de stichtite trouvée dans le massif de serpentines du Bou-Oufroh, Maroc.* Compt. Rend. Acad. Sci. Paris, 1942, vol. 215, pp. 420–422.

Silky lamellae, very pale violet-rose in colour and enclosing chromite and magite, have straight extinction with positive elongation, a' 1·543, γ' 1·562, pleoism feeble. Analyses of material soluble in dilute HCl, Al_2O_3 2·08 (2·06), O_3 6·19 (4·92), Fe_2O_3 13·90 (14·18), FeO 0·31 (0·16), MgO 37·34 (38·26), $_2$ 7·86 (8·50), H_2O+ 32·52 (31·92), agree with $9MgO.(Fe,Cr)_2O_3.2CO_2.18H_2O$. rmal and X-ray data agree with those for stichtite from Tasmania and Transl. This ferriferous variety forms a passage to pyroaurite and brugnatellite. L. J. S.

NCHELL (A. N.). *Further studies of the lepidolite system.* Amer. Min., 1942, vol. 27, pp. 114–130, 6 figs.

nalysis I of lepidolite from Ohio City, Colorado; II, lepidolite, Mt. Apatite, burn, Maine; III, lepidolite, Alabashka, Urals; IV, zinnwaldite, Zinnwald, nemia; V, zinnwaldite, Wakefield, Quebec. (I–II by R. B. Ellestad, III–IV F. A. Gonyer.) These new analyses together with 22 from the literature are ulated to the end-members $K_2Li_4Al_2Si_8O_{20}F_4$ (polylithionite), $K_2LiFe_4Al_3Si_6$ F_4 (protolithionite), and $K_2Li_3Al_5Si_6O_{20}F_4$ (for which the name paucilithionite uggested). The deficiency of almost 1 % Li_2O in most analyses is allowed for intimately admixed muscovite (but this makes K_2O too high). Optical data e determined on several flakes of the material analysed (limits quoted below), ne of the values approaching those of muscovite. Graphs show the relation

between chemical composition and the optical properties. [M.A. 5–215; 7–3 8–352, 354.]

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MnO.	MgO.	CaO.	Li_2O.	Na_2O.	K_2O.	H_2O+.	H_2O-.	F.	
I.	49·19	24·81	0·24		2·51	0·05	trace	5·10	0·52	10·25	1·21		6·89	1
II.	49·14	27·66	0·43		1·22	0·05	trace	3·95	0·40	10·13	2·64		5·21	1
III.	50·16	23·54	0·46	1·27	0·79	0·06	0·04	5·34	1·10	10·97	1·39	0·78	6·75	1
IV.	46·74	21·78	1·19	10·22	0·37	0·00	0·00	3·72	0·54	10·37	0·89	n.d.	7·54	1
V.	51·88	20·65	0·79	1·99	2·01	0·00	0·00	5·26	0·51	10·55	1·89	n.d.	7·65	1

I, also TiO_2 0·08, Rb_2O 1·78, Cs_2O 0·19. II, also Rb_2O 1·17, Cs_2O 0·62, TiO_2 0·00. III Cl 0·05, TiO_2 0·00. V, also TiO_2 0·21. III–V, Rb_2O and Cs_2O not det.

	α.	β.	γ.	$\gamma-\alpha$	2V.	Musco % (ca
I.	1·5315–1·5398	1·5586–1·5635	1·5620–1·5668	0·0222–0·0305	35–38°	13
II.	1·5330–1·5516	1·5565–1·5804	1·5584–1·5863	0·0174–0·0347	32–34·4	34
III.	1·5310–1·5390	1·5540–1·5564	1·5574–1·5607	0·0187–0·0297	32–46·5	11
IV.	1·5435–1·5450	1·5729–1·5737	1·5750–1·5757	0·0307–0·0315	30–32	17
V.	1·5357–1·5440	1·5596–1·5671	1·5628–1·5701	0·0234–0·0286	30–39	13

L. J. S.

SCHALLER (Waldemar T.). *Octahedron-like crystals of calcite.* Amer. Min., 19 vol. 27, pp. 141–143.

A specimen from Magdalena, Socorro Co., New Mexico, shows 4 mm. g crystals c (0001) and η (04$\bar{4}$1), $c\eta$ 76° 38′ (calc. 75° 47′). In the few known exam of dolomite showing octahedral habit the rhombohedra are positive, whilst calcite they are usually negative. L. J. S.

LARSEN (Esper S., 3*d*.). *The mineralogy and paragenesis of the variscite nodu from near Fairfield, Utah.* Amer. Min., 1942, vol. 27, pp. 281–300, 350–37 441–451, 6 figs.

The following phosphate minerals are described, and their structural relatio and paragenesis are discussed in detail. The variscite nodules occur in a brec ated zone in limestone and were formed by phosphatic ground-water, no dou from an overlying bed of phosphorite. Later ground-waters, no longer phosphat acted on the variscite to form the several alteration minerals. X-ray data a given for: deltaite, a 6·71 Å., α 62° 40′, a 6·98, c 16·10 Å., space-group $C_{3v}^5 = R3$ wardite, a 7·04, c 18·88 Å., $C_4^2 = P4_1$ or $C_4^4 = P4_3$; gordonite, a 5·25, b 10·4 c 6·97 Å., α 107° 20′, β 111° 12′, γ 72° 12′.

	Sp.gr.	α.	β.	
Variscite, $AlPO_4.2H_2O$, orthorhombic	2·52	1·569	1·586	1·5
Pseudowavellite, $CaAl_3(PO_4)_2(OH)_5.H_2O$, rhombohedral	2·92	1·619		1·6
Deltaite, $Ca_2Al_2(PO_4)_2(OH)_4.H_2O$, rhombohedral ...	2·95	1·640		1·6
Wardite, $CaNa_4Al_{12}(PO_4)_8(OH)_{18}.6H_2O$, tetragonal ...	2·81	1·590		1·5
Millisite, $Ca_2(Na,K)_2Al_{12}(PO_4)_8(OH)_{18}.6H_2O$, tetragonal?	2·83	1·584	1·598	1·6
Lehiite, $Ca_5Na_2Al_8(PO_4)_8(OH)_{12}.6H_2O$, monoclinic? ...	2·89	1·602	1·616	1·6
Dennisonite, $Ca_3Al(PO_4)_2(OH)_3.H_2O$, hexagonal? ...	2·85	1·591	1·601	
Gordonite, $MgAl_2(PO_4)_2(OH)_2.8H_2O$, triclinic	2·23	1·534	1·543	1·5
Englishite, $Ca_4K_2Al_8(PO_4)_8(OH)_{10}.9H_2O$, monoclinic?	2·65	1·570	1·572	1·5
Overite, $Ca_3Al_8(PO_4)_8(OH)_6.15H_2O$, orthorhombic ...	2·53	1·568	1·574	1·5
Montgomeryite, $Ca_4Al_5(PO_4)_6(OH)_5.11H_2O$, monoclinic	2·53	1·572	1·578	1·5
Sterrettite, $Al_6(PO_4)_4(OH)_6.5H_2O$. orthorhombic ...	2·36	1·572	1·584	1·6
Dehrnite, $Ca_6(Na,K)_2(PO_4)_4(OH)_2$, hexagonal?	3·09		1·58–1·64	
Lewistonite, $Ca_{15}(K,Na)_2(PO_4)_8(OH)_8.4H_2O$, hexagonal?	3·06	1·613	1·623	1·6

L. J. S.

LACHE (Charles) & LEWIS (Lyman W.). *Crystallography of azurite from Tsumeb, Southwest Africa, and the axial ratio of azurite.* Amer. Min., 1942, vol. 27, p. 334.

ist of errata in the angle tables in a paper published in 1927 [M.A. **3**–359].
L. J. S.

HLSTROM (Ernest E.). *Use of ammonium hypophosphite in determinative mineralogy.* Amer. Min., 1942, vol. 27, pp. 385–386.

he powdered mineral (0·1 gram) is fused with ammonium hypophosphite rams) in a porcelain dish. The various colours when hot and cold or when istened with water or H_2O_2 are characteristic of Co, Ti, W, V, Cr, U, Mo, Mn, Nb.
L. J. S.

NELLA (Vincent P.). *Pleonaste from Mineral County, Nevada.* Amer. Min., 1942, vol. 27, pp. 462–463; abstract, p. 222; correction, p. 654.

lenticular mass (50 feet long and 2 feet wide) of pleonaste occurs in dolomitic estone near a granite contact in the Garfield Hills. The mineral is dark green nearly black and finely granular with some well-formed octahedra 4 mm. oss. Sp.gr. 3·530, n 1·725. An obviously incorrect chemical analysis is given.
L. J. S.

IALLER (Waldemar T.). *The identity of ascharite, camsellite, and β-ascharite with szaibelyite; and some relations of the magnesium borate minerals.* Amer. Min., 1942, vol. 27, pp. 467–486, 2 figs.

revious values for the refractive indices of ascharite from Aschersleben, Ger- ny, are too low, owing to admixed water-soluble salts. New values are α 1·58 ng the fibre and γ 1·65 $\perp$ fibre. Analysis gave B_2O_3 40·17, MgO 47·12, R_2O_3 9, H_2O 12·00, insol. in HCl 0·10 = 99·68 (water above 400° 10·90 %) agreeing h $2MgO.B_2O_3.H_2O$. Published data are tabulated and compared; the average ues are α 1·575, β 1·646, γ 1·650, 2V 25°, sp.gr. 2·65. Optical data are tabulated a number of magnesium borate minerals, and graphs show the relation between physical characters and chemical composition for the isomorphous series ibelyite–sussexite and the fluoborites ($3MgO.B_2O_3.3MgF_2$–$3MgO.B_2O_3.3Mg H)_2$). [M.A. **1**–375, **2**–565, **3**–316, **4**–143, **7**–122, 463.]
L. J. S.

RDOCH (Joseph). *Crystallographic notes: cristobalite, stephanite, natrolite.* Amer. Min., 1942, vol. 27, pp. 500–506, 1 fig.

ristobalite is usually octahedral in habit. Small (½ mm.) cubes and rarely o-octahedra have been found on fracture surfaces of olivine-basalt near Two ers, Plumas Co., California; some are interpenetrating spinel twins. Stephanite unknown locality) showed 17 crystal-forms, with some differences in form elopment at the two ends. Natrolite from San Benito Co., California, has form of square prisms (100) (010) with only small (110) and seven terminal ns including new t (351) [Dana's axes].
L. J. S.

UFFMAN (Albert J. *Jr.*). *Fibrous sepiolite from Yavapai County, Arizona.* Amer. Min., 1943, vol. 28, pp. 512–520.

ompact white material from a contact zone near the Santa Maria river shows polarized light a fibrous structure with parallel extinction and positive

elongation, 2V 40–60°, negative, α 1·490, γ 1·505. Analysis, SiO_2 54·83, Al_2O_3 0·
Fe_2O_3 0·45, MgO 24·51, CaO 0·55, Na_2O 0·35, K_2O 0·03, H_2O+ 10·74, H_2
8·18 = 99·92, agrees with $2MgO.3SiO_2.4H_2O$. X-ray powder spacings are ta
lated. These results are compared with data for sepiolite from other localit
Because of the fibrous crystalline structure the mineral is referred to parasepiol
L. J. S

Stevens (R. E.) & Schaller (W. T.). *The rare alkalies in micas.* Amer. Mi
1942, vol. 27, pp. 525–537.

Determinations of Li, Na, K, Rb, and Cs were made on 43 samples of vari
kinds of mica, mostly from pegmatites. Lepidolite contained the largest amo
of the rare alkalis, averaging in 17 samples Li_2O 4·90, Rb_2O 1·35, Cs_2O 0·24
in 6 biotites Li 0·71, Rb_2O 0·59, Cs_2O 0·30 %; and in 12 muscovites Li_2O
Rb_2O,Cs_2O 0·06 %. There appears to be an increase in the rare alkalis du
successive stages of hydrothermal replacement of pegmatites. L. J. S

Palache (Charles) & Berman (Harry) [1902–1944]. *Boulangerite.* Amer. Mi
1942, vol. 27, pp. 552–562, 1 fig.

Goniometric measurements of acicular crystals ($< \frac{1}{2}$ mm. thick and up
10 mm. long) of boulangerite from Rocker Gulch, Deerlodge, Montana, show
49 crystal-forms in the striated prism zone and as minute terminal faces, and ga
$a:b:c = 0{\cdot}9158:1:0{\cdot}3456$, β 79° 20½′. The needles are very brittle, the slighte
pressure causing them to break into leaf-like flakes along the cleavage (100
X-ray photographs gave a 21·47, b 23·16, c 8·00 Å., β 79° 19′, space-group $P2_1/$
sp.gr. 5·98, $8(Pb_5Sb_4S_{11})$ in the unit cell. Goniometric measurements were al
made on crystals from Gold Hunter mine, Mullan, Idaho ('mullanite') and fro
Cleveland mine, Stevens Co., Washington. An angle table is given for 60 cryst
forms. Analysis by F. A. Gonyer of material from Washington gave Pb 55·2
Sb 25·40, S 18·19, Fe 0·39, insol. 0·62 = 99·88. [M.A. 8–6.] L. J. S.

Wayland (Russell G.). *Composition, specific gravity and refractive indices
rhodochrosite; rhodochrosite from Butte, Montana.* Amer. Min., 1942, vol. 2
pp. 614–628, 1 pl., 2 text-figs.; correction, p. 720.

Many analyses from the literature together with some new partial analyses a
plotted with $MnCO_3$, $FeCO_3$, $CaCO_3$, and $MgCO_3$ at the corners of a tetrahedr
which is unfolded as a flat diagram, and lines of equal sp.gr. and ω are show
The isomorphous series $MnCO_3$–$FeCO_3$ and $MnCO_3$–$CaCO_3$ appear to be complet
and $MnCO_3$–$MgCO_3$ is incomplete. Sp.gr., ω, and ϵ calculated from the compos
tion are compared with the observed values, but it is not possible to deduce t
composition from these values. The values assumed for the end-members are:

	$FeCO_3$.	$MnCO_3$.	$MgCO_3$.	$CaCO_3$.
Sp.gr.	3·89	3·70	2·96	2·715
ω	1·875	1·816	1·700	1·658
ϵ	1·633	1·597	1·509	1·486

Large quantities of rhodochrosite ore have been mined at Butte from veins i
quartz-monzonite. The colour is deep rose to grey and cream and the grain-si
0·1 mm. to over 6 cm. Some of the grains show zonal colour banding with vari
tions in the refractive index. [M.A. 1–10.] L. J. S.

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